SOUTH DAKOTA

Geological Survey

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Report of State Geologist

1908

ELLWOOD CHAPPELL PERISHO

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LETTER OF TRANSMITTAL

State Geological Survey,
University of South Dakota,
November 11th, 1908

Hon. E. C. Ericson, President, and Members of the Board of Regents of Education:

Gentlemen:

I have the honor to submit herewith the accompanying articles for publication as Bulletin No. 4, of the State Survey. The reason for the long interval between the publication of Bulletin No. 3, and this report, is evident when it is stated that in the Summer of 1905, the State Geologist's Report, along with field notes, maps, etc., were all destroyed at the time of the burning of the West Hall, and subsequent to the loss the Survey was entirely without funds for two years.

It is very much to be desired that the necessary appropriations will be made to continue the work of the Survey as suggested in an article of this report.

Very respectfully,
ELLWOOD C. PERISHO,
State Geologist.

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PRELIMINARY REPORT ON THE GEOLOGY OF THE NORTHWEST-CENTRAL PORTION OF SOUTH DAKOTA

By J. E. Todd.

Introduction

Why This Report.

The occasion for this report is the retirement of the writer from the position of State Geologist. A reconnoissance was made through the region covered in this report in the year 1902. It had been hoped that further exploration and investigation might be made before the whole was written up. But under the circumstances it seems necessary to put the information now in hand into form for ready reference if not for direct publication.

As this necessitates a map, such an area is taken as will include the whole of the reconnoissance. Hence it has been thought best to embody all reliable data that the knowledge of the retiring State Geologist may be secured to the State. Moreover, as the region covered is likely in the near future to be much inquired about by immigrants and investors, it has seemed wise to make the report as complete as possible.

Sources of Information.

First, and most important, the reconnoissance made by the State Geological Survey in 1902 which will be described later.

Second, the reconnoissance made by the writer at his own expense in 1890, before he was a resident of the State, and in company with Rev. T. L. Riggs of Oahe, whose intimate acquaintance with the region and with the Indians was a great help. The route taken was west of the Missouri, from Oahe to the mouth of the Cheyenne River, and some miles up the Missouri, then back up the Cheyenne to Collamer. Thence by direct trail north past Little Eagle to Ft. Yates, making short digressions eastward to Virgin Creek, west on the divide north of the Moreau and to the fossil field near Little Eagle.

Third, Bulletin 21 of the United States Geological Survey, entitled "The Lignites of the Great Sioux Reservation," which gives brief report, sections, and topographic map of about 2,000 square miles between the Moreau and Grand Rivers, reaching from Rabbitt Butte on the west to Fire Steel Creek on the east. The work was done by Mr. Bailey Willis, geologist, and F. J. Knight, topographer, in 1884.

Fourth, for the portion along and east of the Missouri River, data are embodied from the work of the writer done in 1883 and 1887, and published in Bulletin 144 of the United States Geological Survey.

Fifth, advantage has been taken of the very complete map of the Missouri River published by the United States Corps of Engineers. This with the topographic maps of the United States Geological Survey, around the Black Hills, and Bulletin 21 have been of great service in determining the elevations of the principal streams which have been the "control" in reducing the barometric observations made.

Sixth, Mr. H. Kippax of the State Surveyor General's office has furnished the writer with important field notes of the land surveyors, referring particularly to lignite deposits.

Seventh, data on the artesian wells have been kindly furnished by several different parties, but particularly by Messrs. Norbeck and Nicholson, who have made most of the wells in our area. Besides, the writer took a trip through Sully County in 1901 for this purpose.

The Reconnoissance of 1902

Because of popular reports of coal finds in this region, because it was thought to be as promising as any in the State for a discovery of petroleum or gas, and because it was a portion almost unknown to the scientific mind, the State Geologist planned to make a trip through it as early as 1901. That year, however, the expedition was given up because of prevalence of small-pox among the Indians.

In 1902 this objection disappeared, and as early as funds were available, preparations were made, and the party gathered at Pierre, July 12. The party consisted of the State Geologist, Robert W. Ellis, B. S., volunteer assistant geologist; Sheridan R. Jones, B. A., zoologist; Henry Ramsey, B. S., botanist; Clyde H. King, general assistant. A lumber wagon and a spring wagon, both covered, with teams and saddle horses were hired of Mr. E. Jacobson of Pierre, and A. B. Collins of Canning, the latter going with us as teamster and interpreter.

Having obtained supplies sufficient, we proceeded by direct route to Forest City, where we crossed the Missouri. We then took the direct trail to the Moreau River, a little below White Horse Camp, making a side trip up Virgin Creek. We then went up the Moreau to the mouth of Green Grass Creek. Our side trips were made particularly to the northwest to examine the conspicuous buttes on Meadow Creek. Thence we proceeded by trail to Leslie on the Cheyenne River, where a side trip was made south over the divide into the basin of Bad River. We then crossed back to the Moreau by a different trail and struck that stream near the mouth of Flint Rock Creek. From this point we examined Thunder Butte and Arrow Head Hills, and also made a trip down the Moreau to the top of Fox Hills formation.

We then proceeded up the Moreau and Rabbit Creek to a point on Antelope Creek south of Rabbit Butte. From this point side trips were made to Bixby, to Rabbit Butte and vicinity and a party was sent to the South end of Slim Buttes. We then returned to the Deadwood and Bismarck trail where it crosses Rabbit Creek, which we followed to Grand River, making digressions to Coal Springs and Black Horse Butte. Thence we followed the regular trail down the Grand River to Sec. 18, T. 20 N., R. 21 E., where we came and made side trips up Black Horse, Meadow, Cottonwood and Dirt Lodge Creeks. We then went down the river to the vicinity of Bull Head station, where a day or two was spent in collecting Fox Hills fossils. We then left the river, going by direct trail to Little Eagle, where we spent another day collecting fossils. Thence we continued down the Grand River and the Missouri to Evarts, where most of the party took the light wagon, crossed and made their way to Pierre; thence to their homes on August 21st.

The State Geologist and Mr. Collins took the trail west from Evarts to the Soda Lake near the Little Moreau, T. 17 N., R. 25 E. The purpose was to go farther west, but threatening storm and possible difficulty in crossing streams decided that we should turn south down the Little Moreau, crossing the Moreau River near White Horse Camp, and thence south, crossing the Cheyenne River at Angel's, and on past Standing Butte to Pierre, where we arrived August 28th.

Altitudes.

The altitudes along the Missouri are taken from the maps of the Missouri River Commission. The topographic sheets of the U. S. G. S. covering the region of the Black Hills have been consulted in determining the slope of the Cheyenne River. The topographic survey made by Knight as recorded in Bulletin 21, U. S. G. S., though less accurate, has been followed in determining the slopes of Moreau and Grand Rivers also for the altitudes of prominent points in the area which he examined. Using these streams as a control, the rest of the surface has been determined by the readings of an aneroid barometer along the line of exploration and the rest of the surface is estimated from the courses of streams and general views. The contours must be considered as only approximate.

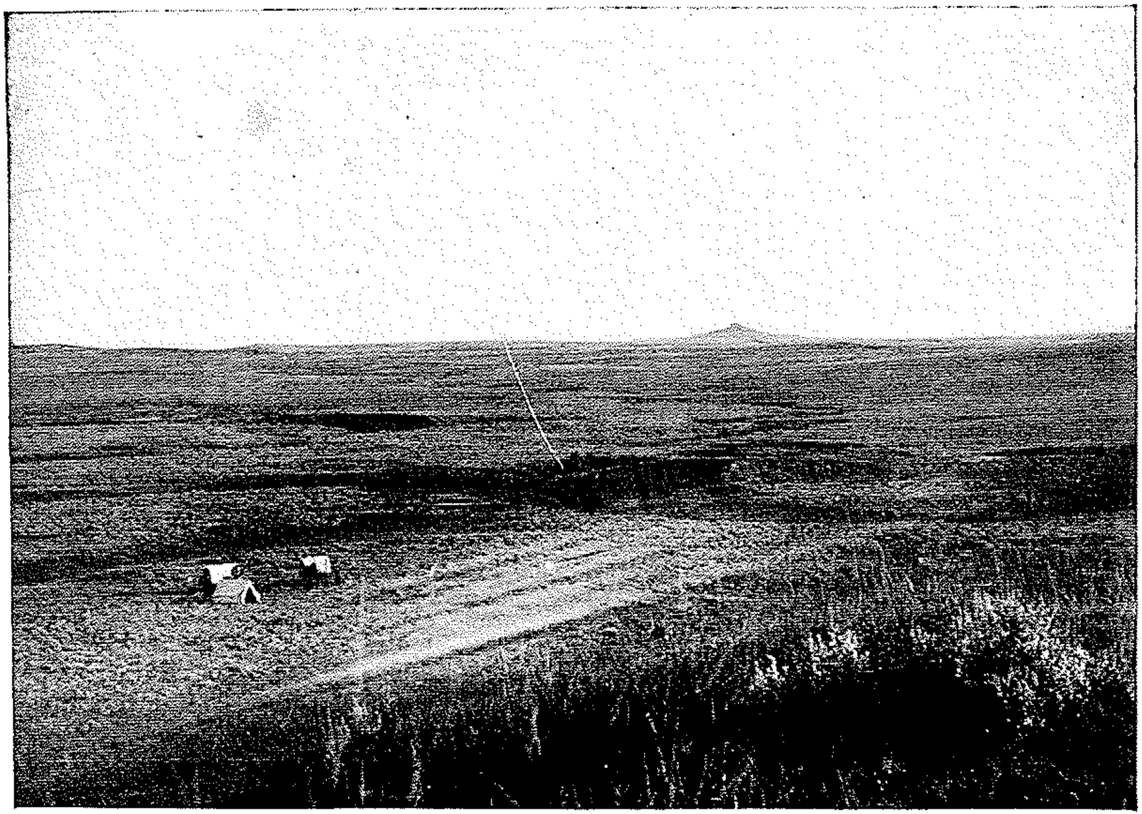
Geography

The area under consideration belongs entirely to the region known as "The Plains," which slopes from the foot of the Rocky Mountains to the Missouri River. Its relief is intensified by the greater nearness of the river, also by the disturbing influence of glacial conditions at a comparatively recent stage.

Location and Limits.

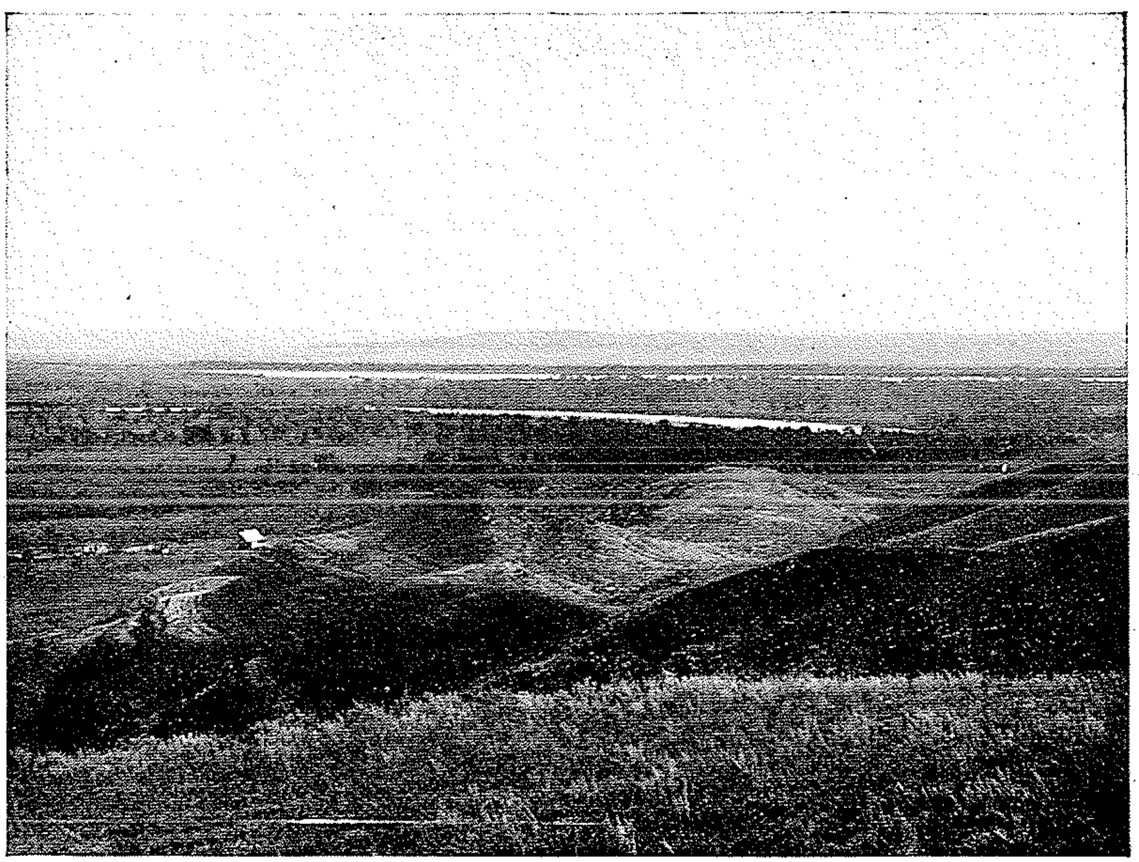
The area discussed is a rectangle bounded by meridians, one a little west of 103 and the 100th from Greenwich, and by parallels, the north line of the State and the first standard parallel north of the Black Hills base line. It includes over 14,000 square miles.

Plate 1.



A. Rabbit Butte from Antelope Creek, looking north.

Plate 2.



B. Cheyenne and Missouri rivers, looking east.

TOPOGRAPHY.

Though it is probably generally thought of, and spoken of as a plain, that term gives quite an erroneous impression to most minds. While its general upland surface rises and falls through moderate range with gentle slopes, yet, upon this conspicuous masses and buttes rise quite abruptly to a height of 100 or even 400 feet, Plate 1. And, on the other hand, the rivers and water courses have cut a like distance below it, while along the larger streams are several terraces, often wide and sharply defined, Plate 2. The plain slopes quite regularly from about 3,200 feet along the western side of the area to about 2,000 feet along the eastern. The highest point in the area is on the Slim Buttes, estimated to be about 3,500 feet A. T. The lowest near Pierre in the Missouri channel is about 1,400 feet A. T.

The occurrence of the sandstone strata, lying nearly horizontal and quite persistent over considerable areas, and separated by much quicker masses of sands, clays and loams, under the action of erosion has done much for the picturesqueness and variety of the surface. While the surface of the table lands may be monotonous, one is usually not long out of sight of some majestic or mysterious land mark. And as he nears a river valley his eye revels in the magnificent views of terraces, buttes and ravines, of fertile valleys, colored cliffs, and green slopes. Because of the prominence of two or three of such sandstone horizons, there are as many belts of buttes traversing the area from north to south. As each belt is approached from the east, the buttes are at first few and high; then lower and more numerous gradually grading into mesas and table lands, upon which the next series may later be found appearing in similar order. It follows from this that buttes will also be more numerous and scattered in the sides of river valleys.

The river terraces we shall discuss in a subsequent section, and will only say here that flat top buttes near streams sometimes prove to be really portions of a much eroded river terrace, and such has been the amount of the erosion of the dark clay of the Pierre formation in the southeast portion of our area that such buttes tower above all surrounding surface, 600 feet or more above the Missouri, nearby.

A word should be added concerning Fox Ridge, which has formed so conspicuous a feature on early maps. It is essentially a misnomer, based on a misconception, which very naturally sprang up in the minds of early voyageurs and explorers as they gazed from their boats on the Missouri or Cheyenne Rivers at the abrupt southern edge of the table land north of the latter stream. The distance and the presence of the hostile Indians seems to have prevented its early exploration.

The contour line upon the map with profiles and photographs give truer conceptions of topography than can be expressed in words.

Drainage.

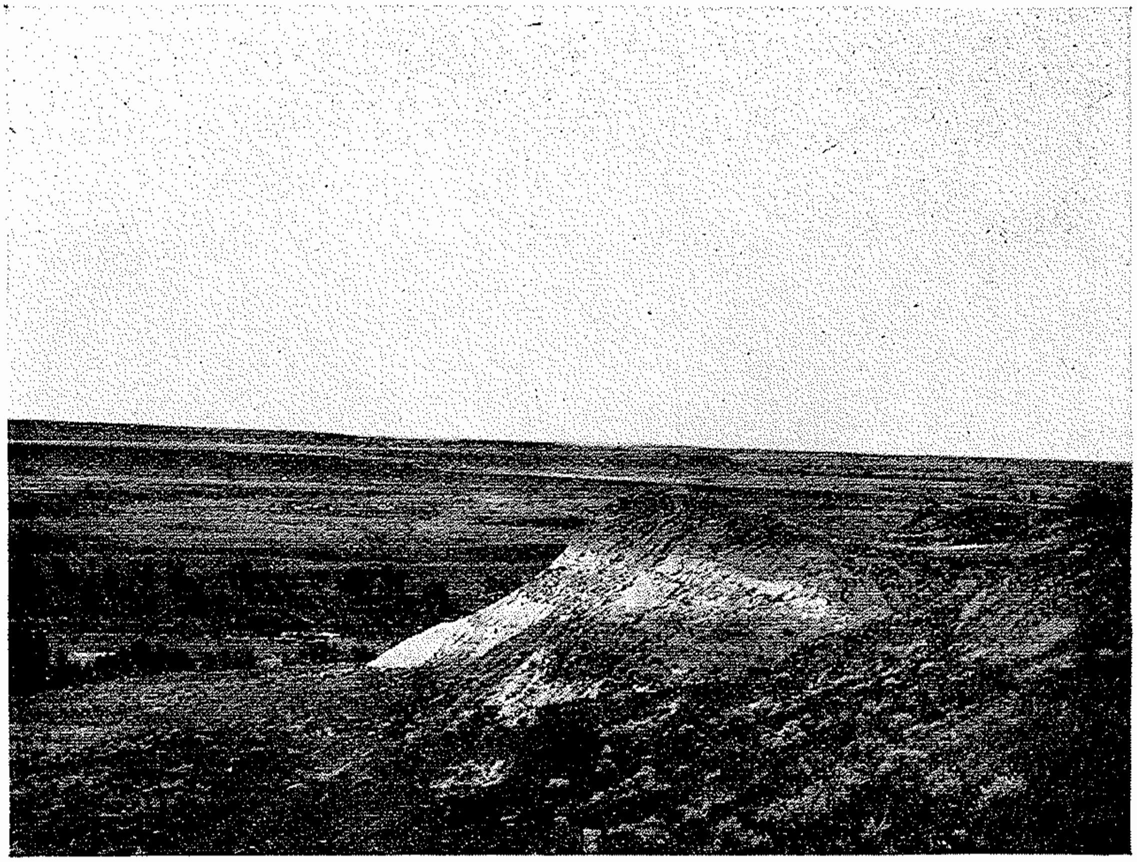
The whole region belongs to the Missouri River system, and drains towards the east. The exceptional course of the Missouri, which is at right angles to the general slopes, has been satisfactorily traced to the interference of the great glacier which came to the James River valley during the later Pleistocene.

Streams.

The Missouri River at ordinary stages is less than a quarter of a mile wide, and from 3 to 12 feet in depth; the latter rarely found. Its trench is often twice that in width, and more than twice that in depth. It is about 1,563 feet A. T. at the north line of the State, and about 1,410 at the south line of our area. The bottom of its trough is usually a mile in width, and from 300 to 500 feet below the adjacent upland, which often abuts abruptly on the valley. There are terraces commonly showing on one or both sides sometimes as many as 4 or 5, varying from 25 feet to nearly 400 feet above the stream. Those over 100 are largely composed of glacial drift. The height and relations of these terraces are illustrated in the sections and views, and they will be further treated under Geology. There are no important rock strata appearing in the sides of the valley. The abrupt changes in slopes are due either to boulder beds or zones of concretions.

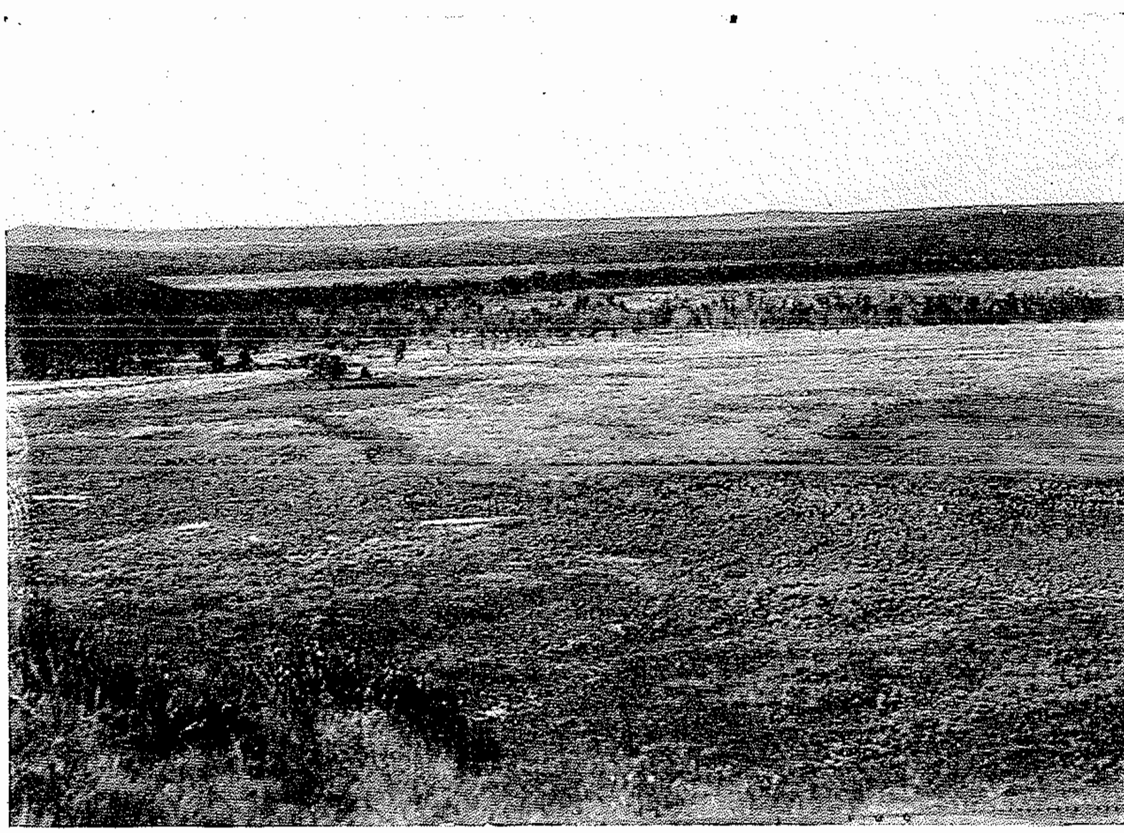
The slope of the stream is a little less than one foot to the mile, and the current rapid. It is quite subject to floods which sometimes rise 20 feet above ordinary low water. The high floods occur in the spring, which are not frequent, and in June when

Plate 3.



A. View down Grand river, from top of terrace east of Cottonwood creek.

Plate 6.



B. View down Moreau river from Rabbit creek toward Arrow-head Hills.

the melted snow from the mountains appears. The water is always turbid, except in winter, and the clay in its settling carries down all the impurities, so that the resulting clear water is noted for its softness and purity.

Among the more important smaller tributaries of the Missouri in this area is Oak or Rampart Creek, named from the trees along it, and from the buttes which rise like fortifications near it. This stream is usually dry in its upper portion.

On the east side we find Spring Creek, which enters the Missouri at La Grace, the Blue Blanket or Bois Caché, which enters at Evarts. The Swan Lake Creek at Le Beau, Little Cheyenne at Forest City, and Okobojo Creek at Fielder. All of these streams usually have running water near the river, but in their upper courses only in water holes most of the season. Their valleys are usually large in proportion to their size, owing to the fact that they were formerly much larger during the Glacial period. They have few, if any, groves along them. In this respect they differ from the streams of corresponding size west of the river.

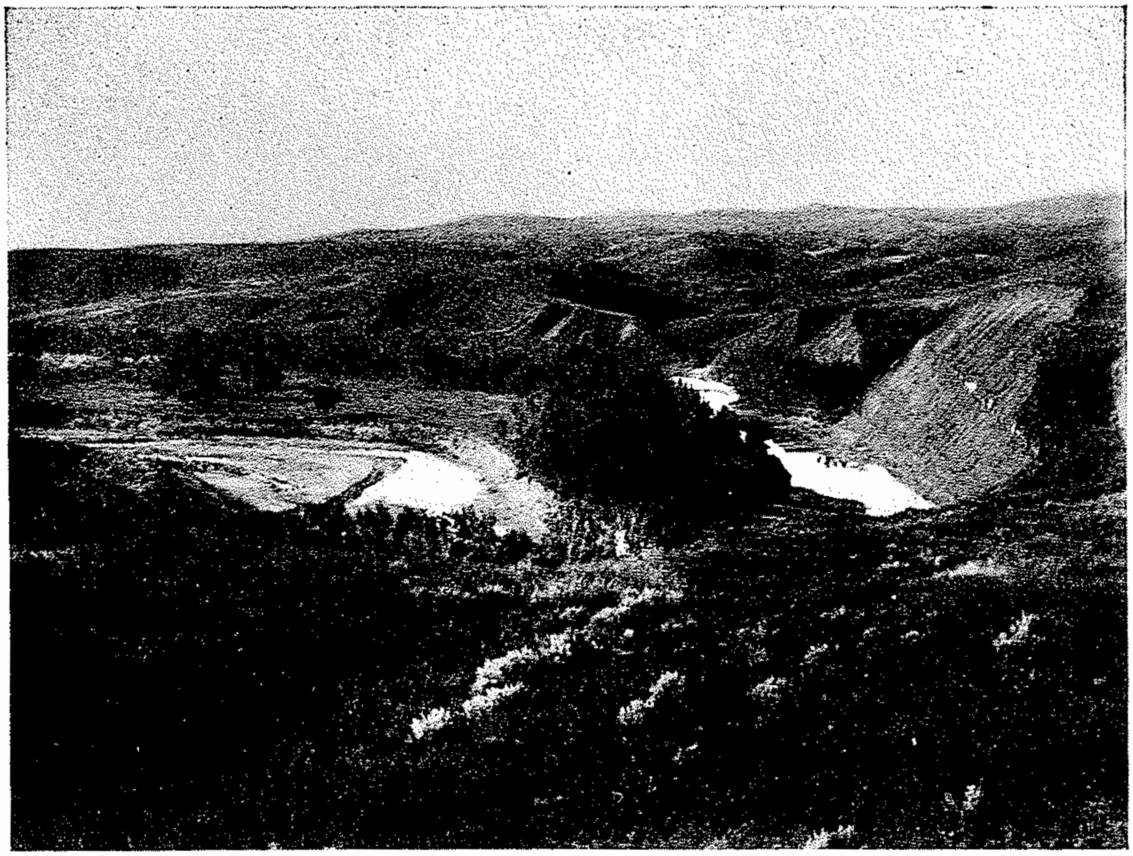
The Grand River arises in two principal branches in western Butte County, which join before they leave the county. The northern branch is more sandy and clear; the southern, rising in Tertiary beds resembling those of White River, is milky and with more clayey banks. The course of the stream is quite directly eastward though it is very crooked through most of its length. It has carved its valley mostly out of very soft strata. At a few points low cliffs of massive sandstone appear as near the mouth of Dirt Lodge Creek, and at a few points between that and Little Eagle. It is usually a clear, rapid, shallow stream, easily forded, because sand and gravel are common, and because the stream at ordinary stages occupies a small part of its whole trench. The trail down it crosses nearly every bend. In extreme droughts it sometimes ceases to flow over much of its course. Yet, it is subject to sudden floods, which for short times render it impassable. It has a slope when measured parallel with the axis of its valley of about 7¾ feet per mile, but about one-third of that along its current. The stream at Little Eagle at ordinary stages is less than one rod wide, and less than one foot deep, though its trench is nearly 300 feet wide, and 8 or 10 feet deep. Its bends are usually cutting great amphitheatres in the sides of its trough, so that fine exposures of clay strata appear 100 and sometimes nearly 200 feet in height. There are about three low terraces or bottoms, usually about 10, 25 and 50 feet above the stream. Each is frequently subdivided; the lower usually has trees upon it, and is more or less sandy, and it is mainly alluvial material. The higher ones have no trees, except in ravines, but usually luxurious vegetation. They, as all higher ones, are largely composed of the country rock, though capped with alluvium. Two or three high terraces are found sometimes, over a mile in width. Though varying much and subdivided often, they naturally group themselves about 100 and 200 feet above the stream. In general, they slope less rapidly than the river, so that they are higher, and have become more removed by erosion, so that they are less frequently represented. Plates 3 and 4.

Of the principal branches we may name upon the north, Flat Creek, Dirt Lodge Creek, Hump Creek, Spring Creek, Rock Creek and Hickory Creek. Upon the south, Black Horse Butte, Cottonwood, Fire Steel, High Bank, Deep Bank and Snake creeks. Of these all usually have running water in them over most of their course, except the last three, which in later summer are usually dry, at least in their lower course.

The Moreau River resembles the Grand in its rising in two branches, in its earsterly course, its crooked channel, its high cut banks, its numerous terraces, in its drying up in time of drought, and in its sudden floods. It is not so large a stream, has more clayey bed and banks, and its two main branches meet sooner. It has sandstone cliffs only for a short distance between Flint Rock Creek and Rabbit Creek. Its bottoms seem a little more fertile, and its trees are more abundant. The Indian name for it is Owl River, which agrees with the latter statement. Plates 5, 6, 7 and 8.

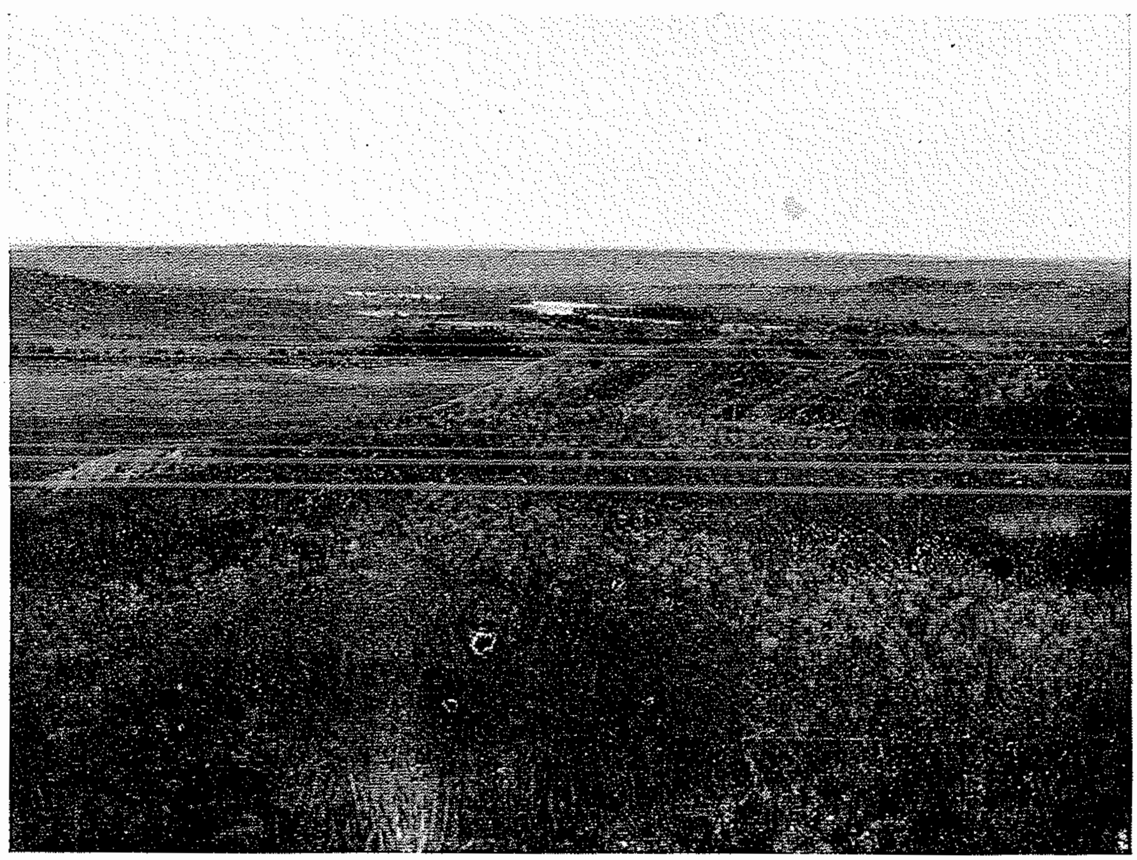
Its principal tributaries are as follows: Rabbit Creek, which heads in several branches along the east slope of Slim Buttes, which after joining together, keep a constant southeast direction; Flint Rock, which rises in northeast Meade County, and after east northeast course turns abruptly north and enters Moreau a few miles east of Arrow Head Hills. It obtains its name doubt-

Plate 7.



A. Sharp bend on Moreau near mouth of Green Grass creek. Pierre clay topography, looking east.

Plate 10.



B. Junction of Cheyenne and Cherry creek looking northwest, from high terrace, Plum creek on the left.

less from the flint concretions in the different buttes near it, from which the Indians obtain flint for their arrow heads; Thunder Butte Creek, which starts a little east of Slim Buttes, and runs parallel to Rabbit Creek, which resembles it in several respects. It flows by Thunder Butte from which it takes its name.

Worthless, Red Earth, Meadow, Red Water and Little Moreau creeks, all rise in the narrow table lands north, and take a southeastern course to Moreau. Their names, like most in this region, are of Indian origin, and are more or less expressive of some distinguishing character in each. The last is the largest, and has the most permanent water; it also has more trees along it.

Elm or Bear Creek in its upper eastward course, has a shallow open valley, turning north it cuts a deeper ravine-like valley. Green Grass, Goose and Virgin Creeks also enter Moreau from the south, and all have cut deep valleys, and have running water.

The Cheyenne River is the largest tributary of the Missouri in this State. At its mouth in ordinary stages, it is 50 to 100 feet wide, while at flood, which comes suddenly and at irregular intervals, it becomes a torrent, filling its bed to the brim, and often over-flowing. Its trench or bed near its mouth is one to two hundred yards wide, and six to ten feet deep. It rises in Wyoming, and with its two branches encircles the Black Hills. Because of its copious supply and torrential action, few rivers in its region match it in the amount of erosion which it has accomplished in comparatively recent times.

At the 103rd degree west longitude, the Cheyenne River has an altitude of 2,400 feet A. T. At the mouth it is 1,468 feet, giving a slope if regular of about 8 feet per mile, but the slope west of the 103rd degree is over 11 feet to the mile on the north branch, and still greater on the south branch. So we assume a change of slope at the junction of the two, and take that arbitrarily at 2,000 feet A. T. The slope below that point will then be about 6. 4 feet per mile in the axis of the valley. It resembles the Grand and Moreau Rivers in its crooked course and its high cut banks, and surpasses them in the breadth and fertility of its flood plain. Figs. 9 and 10.

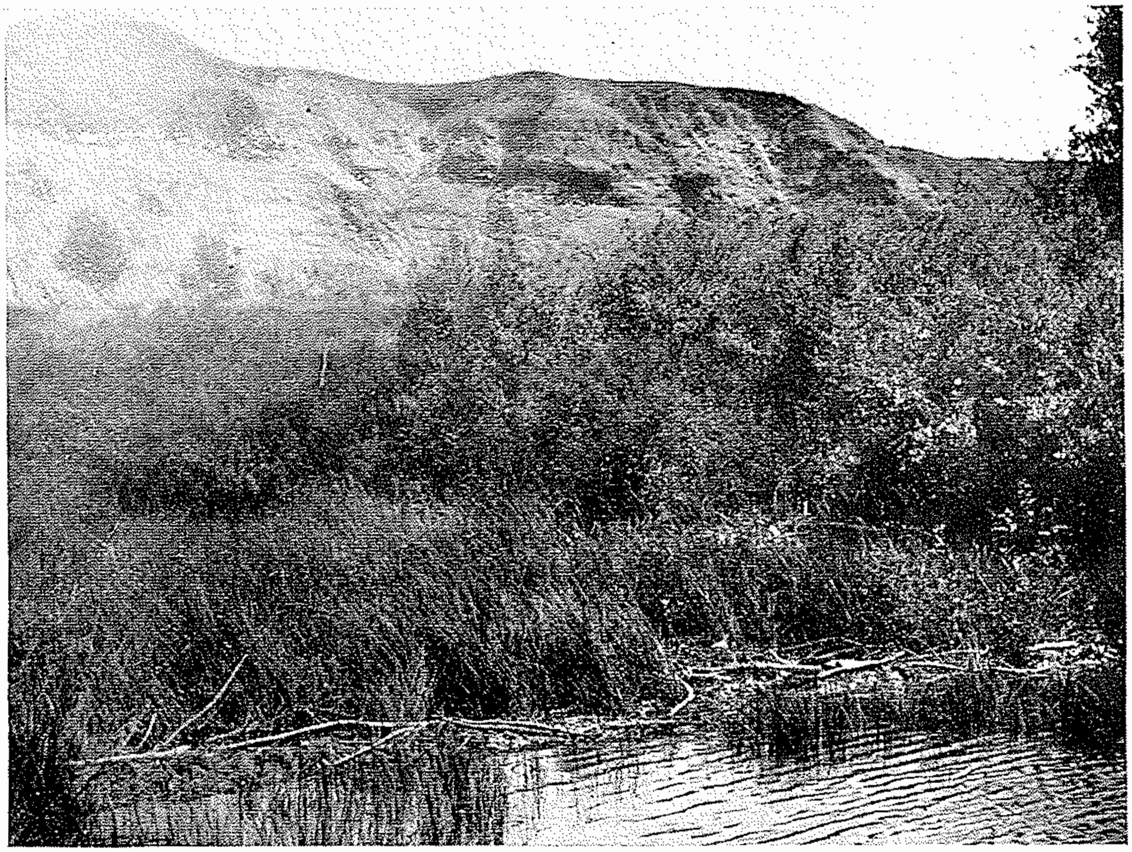
The Cheyenne has but one tributary of any size in this area, namely, Cherry Creek. Others are little more than long, deep ravines with occasional springs. Cherry Creek rises in several branches in the rough region of Owl Butte. Flows first southeast, then parallel with the Cheyenne, then abruptly turns to unite with that stream at Leslie. It has a deep valley and high terraces like the Cheyenne itself. In its lower course it is nearly as prominent as the Cheyenne. The smaller branches of the Cheyenne flow largely in the Pierre clays. Wholly so, south of the stream, and through their middle and lower courses north of the Cheyenne. Their waters when low are apt, therefore, to be impregnated with mineral salts, or "alkali."

Bad, or Teton, River flows almost entirely over these dark clays of the Pierre, which do not absorb or dole out the water by any considerable sandy lining of its trough. Hence its water in the dry season stands in pools, is alkaline, and generally has a bad taste from the mineral salts contained. Owing to the highly plastic clays of its banks, and the ease with which the land slides take place, high cut banks are not common, and terraces are not so large. Its limited basin has rendered it a less vigorous stream in every way. At ordinary stages it is 50 to 75 feet wide at its mouth. Only a small part of its basin lies within this area, and we have not personally examined it.

Vegetation.

The report on the plants collected by Mr. Ramsey has not yet been prepared, and we take space here only for some very general notes, leaving further elaboration to illustrate our discussion of soils. The region is open prairie, except on the low flood plains of the principal streams, and the deeper ravines cutting the edge of the table lands. The Missouri, Grand, Moreau and Cheyenne are skirted with continuous strips of cottonwood, elm, ash and associated shrubs throughout this area. And their principal tributaries Cherry Creek, Plum Creek, Rabbit Creek, Flint Rock Creek, Little Moreau and Virgin creeks, also Bonesteel, High Bank, Hickory and Deep Bank creeks have scattered groves in their lower and middle courses and again to a less degree in their open valleys on the upland. Groves are more abundant and larger than along the streams east of the Missouri.

Plate 11.



A. Beaver dam on Rabbit Creek.

Plate 13.

B. View of junction of Missouri and Little Cheyenne. Landslides of Pierre clay in the foreground.

Oak and hackberry appear upon some of the deeper sandy soils, particularly in the ravines in the Fox Hill formation. Red pine appears in similar circumstances farther west, particularly on the Slim Buttes. They are found as far west as Arrow Head Hills. Grass covers the surface elsewhere, except in very limited areas of Bad Lands. Its varieties and their distribution will be discussed in connection with soils. On the dry flats connected with the Laramie Bad Lands and the Pierre formation, the common cactus, *Opuntia hemifusa* often covers the ground very thickly. This was particularly impressed by a ride up Dirt Lodge Creek. The species ranges through the whole area, and often covers up several acres to the exclusion of all other plants. *Opunta fragilis,* while nowhere very abundant, is generally scattered in place of the other species over most of the Fox Hills region, particularly between the Moreau and Cheyenne Rivers.

Animals.

A report on the animals collected on a trip, has been prepared and placed on file by Mr. Sheridan R. Jones. We take space here for only a few general observations. Larger animals like the bison, antelope, elk, etc., which once abounded over this area, have entirely disappeared. The coyote and wolf alone remain. Prairie dogs are perhaps as numerous as ever. The larger colonies sometimes cover a square mile or more, and the smaller ones are very common. The striped spermophile is rare, but is replaced toward the north by a tawny species. Traces of beaver were found at several points on Rabbit Creek and Dirt Lodge Creek. Pictures of their work which were taken, are herewith submitted, Plate 11. Porcupines seem to be widely distributed. Two specimens were taken on Antelope Creek.

Of birds, the lark-bunting and western king-bird are always present. The groves along the streams abound in birds similar to those farther east. The sage hen is found in the west portion of the area, and grouse in the eastern portion in place of the prairie chicken found farther east. Of nocturnal birds, the night hawk is common, and owls of several species, and instead of whip-poorwill, the note of the poorwill was heard along the Moreau and Grand Rivers.

Geology

IN GENERAL.

In general, the geology of this area is very simple. Strata are very nearly horizontal, with very few slight local folds and faults of very few feet throw. There are no unconformities, or breaks anywhere near the surface. All the thicker sendimentary rocks are of later Cretaceous age with one very slight representation of the Tertiary. All the drift deposits are quarternary, except possibly a few remnants of the Pliocene. No rocks older than these have been struck in drilling, which has penetrated 300 feet below sea level in Campbell County, and it is likely that no older rocks are nearer the surface than that, unless it be toward the southeast near Pierre.

On the other hand, we find nearly all methods of deposition illustrated, except igneous, viz.: marine and fresh water, the latter including fluviatile, lacustrine, and paludinal; also chemical, and in the extreme eastern portion glacial and aqueo-glacial. Firmly consolidated strata are very thin and of small extent.

PRE-CRETACEOUS ROCKS.

Of the rocks in our area older than later Cretaceous we can only learn by facts obtained from adjacent regions, and from the drilling of deep wells. Crystalline rocks doubtless underlie the whole region, and possibly in the eastern part of the area they lie just below the Cretaceous strata as in most of eastern South Dakota. It is probable that the Cambrian, Ordovician, Carboniferous, Triassic, and Jurassic rocks, which appear in the Black Hills, may extend under very much of this area, especially in its western portion, but borings over 2,000 feet in depth at Gettysburg and Campbell County have not shown their presence in those places, though possibly deeper borings might reach them. Certain carbonaceous or coal-like deposits reported from Pierre at the depth of 1,525 to 1,535 feet may possibly belong to the Carboniferous, but such conclusion has not been proven.

CRETACEOUS ROCKS.

The following formations preceding the Tertiary are all included in the Cretaceous system, and in the "Upper" division of the same by most geologists, though there are reasons for placing the Dakota in the "Lower," as is done by a few.

THE DAKOTA FORMATION.

This has become justly celebrated as the source of the most copious and available artesian wells of our State. It without doubt underlies the whole region under consideration. Its upper surface probably is at a depth of from 1,000 feet at Pierre, and 1,750 feet in Campbell County below the level of the Missouri, to 3,000 or even possibly 4,000 feet below the top of the Slim Buttes of the western part of our area. Further discussion of this will be found in connection with the subject of Water Supply, and much light may be gained by a study of the profiles. These are, however, necessarily based on incomplete data, and must not be trusted implicitly.

THE COLORADO GROUP.

This includes the Benton and Niobrara formations, the latter known also by the name of "Chalk Stone" in the eastern part of the State. These also doubtless underlie the whole region, though the latter may not possess its chalky character. The former is of a clayey character, of a dark color. The latter is also usually of a dark color, although of chalk or limestone, and hence they are not commonly distinguished by well drillers from the Pierre formation, which overlies them. Only the fortunate discovery of a characteristic fossil would decide the case. From the Pierre wells we infer that the Benton there is about 650 feet in thickness, and the Niobrara 155 or 160.

THE MONTANA GROUP.

This includes the Pierre and Fox Hills formations. They are both extensively exposed in our area. Both of them are of a marine origin like the Benton and Niobrara just mentioned.

THE PIERRE FORMATION.

The Pierre formation consists almost exclusively of dark and light-gray clays, usually laminated, and often called soap stones. The coloring matter seems to be largely due to carbonaceous though ferruginous matter is common, that is, due to the presence of vegetables or animal matter as well as to iron. There occur at irregular intervals, levels of limestone concretions, which are usaully biscuit shaped, and sometimes two or three yards across. They are composed both of carbonate of lime and carbonate of iron. The latter may be supposed to have formed during the process of sedimentation. The calcareous ones may also have been so formed but their septarium character and the signs of expansion in the surrounding clay indicate that they have grown long subsequent to the time of the deposition of the clay, and therefore, mark more or less distinct water horizons. See Fig. 7.

This formation is so hardened in some places that it stands well, but generally it gradually absorbs water and becomes plastic, and therefore many land slides occur. Fig. B. This latter feature seems to be more prominent in its lower portion, though it is found more or less at all levels. Some views are given which illustrate this characteristic. It abounds at certain levels in noduels of pyrites, which by weathering produce an acid, which greatly assists in rendering the adjacent beds plastic. This is the source also of gypsum crystals and of gypsum veins and of efflorescent salts like copperas, epsomite, glauberite, etc.

Its Thickness.—Its greatest exposed thickness in our area is between Standing Butte and the Missouri River, where it is about 600 feet. Its base is said by Dr. Hayden, who first defined the formation, as passing below the Missouri River at the great bend, or at an altitude of 1,375 A. T. From the Pierre well as near as can be estimated, from the reported character of drillings, its base is at a depth of 325 feet or 1,115 feet A. T., which corresponds fairly well with the dip and probable thickening of the formation toward the north. The altitude of its junction with the Fox Hills north of the Cheyenne River, is estimated to be about 2000 feet A. T. Allowing for a possible slight anticlinal fold along the Chey--nne with a general dip of its surface to the Northwest, its greatest thickness in this area may be placed at about 1000 feet. Of course, where it is not overlaid by the Fox Hills, it has been greatly thinned by erosion.

Extent of its Exposure.—It comprises the slopes adjoining the Missouri River throughout this area; also those along the Cheyenne. It occupies all the portion south of the Cheyenne, except where covered by river terrace deposits, and east of the Missouri, except where covered by glacial drift. It covers the valley of the Moreau in a slender triangle with its apex in the bed of the stream near the mouth of Worthless Creek. In a similar way, it extends up Grand River nearly to Bull Head Sub-Agency.

The exact limits in the streams have not been determined. In fact, it is quite difficult to trace the exact top of the Pierre for the following reasons: First, the lower Fox Hills, which overlies, resembles the upper Pierre in color and general appearance. On slopes the former is a little more flaky after weathering, while the latter is generally quite plastic. The former has a little grit in it, while the latter has not. Second, both have concretions closely alike. The former is usually very fossiliferous, and the latter have few or no fossils. The concretion of the former are apt to weather red; the latter more frequently turn whitish or gray. These are not infallible signs. Third, both have alternations of hard and soft strata and both have fossils and barren concretions. Moreover, the fossils are not always clearly distinct, though each formation has its characteristic species. Fourth, the Pierre from its plasticity is not likely to keep its level on a bluff or a steep hill side, so that there are apt to be land slides to confuse matters. Pate 13.

After considerable allowance for possible errors, the following table is believed to exhibit quite closely the altitude of the top of the Pierre as it was observed on this expedition:

JUNCTION OF THE PIERRE AND FOX HILLS FORMATIONS.

Northwest of Little Eagle	1933	A. T.
South edge of the table land 20 miles west of Evarts	2020	A. T.
South edge of the table land 27 miles west of Evarts	1950	A. T.
North of Little Moreau	2164	A. T.
East of Meadow Creek, 4 or 5 miles from the Moreau	2270	A. T.
West of Meadow Creek, 5 to 7 miles	2200	A. T.
Southwest of the mouth of Green Grass Creek	2290 (?)	A. T.
South of White Horse Camp	2080+	A. T.
In Virgin Buttes	2025	A. T.
North of Rosseau	2015	A. T.
Northeast of Leslie	2177	A. T.
North of Leslie	2215	A. T.
South of Leslie	2375+	A. T.

This appears to show that the top of the Pierre dips to the north and west, but that there seems to be a dome-like uplift on the Fox ridge about 40 miles west of the Missouri River.

Its Fossils.—A list of these will be given later. We merely note here that the formation as a whole is not very fossiliferous, at least in the area under consideration. The most commonly noted fossil of the Pierre was *Lucina occidentalis.* It appears in concretions 50 to 100 feet below the top of the formation, and also rarely at several levels lower down. *Belemnitella* was found near its middle, west of Pierre, and also near the top on Grand River. Fragments of *Inoceramus* shells are occasionally found in patches and in connection with thin iron concretions at almost any level of the formation; so also *Scaphites* of several species are occasionally found; so also vertebrae of large reptiles.

The Fox Hills Formation.

Its Characteristics.—This formation is a transitional one, between the Pierre and the Laramie. Its boundaries are difficult to define. Its earlier stage is scarcely distinguishable from the Pierre as already stated, but it may usually be recognized by a perceptible amount of grit and sand mingled with the clay. It usually abounds in large lenticular or roughly globular concertions of a rusty color, often but not always, very fossiliferous. As its species are many and some of them common to the Pierre, it is questionable whether it should be considered to be more than a local shallow water development of the Pierre, preceding the Laramie.

Its later stage is not distinguishable lithologically from the Laramie, but its fossils are marine, while those of the Laramie are fresh or brackish water species. In the differentiation of the Fox Hills we have an impressive illustration of the rule that "Nature abhors sharp distinctions."

To ascertain the original conception of the formation, we turn to Dr. F. V. Hayden. He describes the formation as composed of "gray ferraginous and yellowish sandstone and arenaceous clays." He says it begins to appear on the Missiouri near the Cannon Ball River, and extends 50 miles farther south over the Pierre. Also that it covers the country after crossing the Cheyenne River.*

Meeks says of it later, "Toward the base it consists of sandy clays; but as we ascend to the higher beds, the arenaceous matter is found to increase, so that in some places the whole passes into

*Second Annual Report of Progress of the U. S. G. S. of Wyoming, 1872, pages 87 and 92.

a ferruginous sandstone. It is not separated by any strongly defined line of demarkation from the Ft. Pierre group below, the change from the fine clays of the latter, to the more sandy beds above being generally gradual; nor are these rocks distinguished by any very abrupt or strongly marked change in their organic remains, since a part of the fossils occurring in the upper fossiliferous bed of the Ft. Pierre group, also passes up into the Fox Hills group. Indeed, it has been sometimes thought that we might, with almost equal propriety, on paleontological grounds carry the line separating these two groups down so as to include in the Fox Hills group the upper fossiliferous bed of the Ft. Pierre group."*

Willis, following J. B. Marcou, includes the more fossiliferous portion of the Pierre with the Fox Hills, and divides the formation as follows:

FORMATION	FOSSILS	LITHOLOGY
Upper Fox Hills........	*Tancredia Americana, M. and H.*	Brownish Sandstone.
Fox Hills..............	*Cucullaea Shumardi, M. and H.* *Turris contortus.*	Grayish-blue shale below brownish unfossiliferous sandstone.
Lower Fox Hills— (Ft. Pierre of Hayden in part.)	*Volsella attenuata, Scaphites Conradi, var, intermedius, Pteria Nebrascana, Spironema tenuilineata, Cucullaea exigua.*	Dark-gray to blue-black tenacious alkaline clays, locally hardened to compact clay rock.

Bulletin 21, U. S. G. S., page 11.

He makes the remarkable statement that "There is a gradual transition in this lcality from the upper Fort Pierre clays through not more than 100 feet of Fox Hills beds to the lower sandstone of the Laramie." This is an exaggeration, for when dark plastic clays are placed in the Pierre instead of the Fox Hills, our sections at Little Eagle and Meadow Creek make the thickness at least 150 feet. This is illustrated in our general section. It seems in comparing different exposures that the transition from the marine to fresh water form is not always in the same lithological formation. On Grand River it seems to be mostly in sand, on the Moreau in clay.

*U. S. G. S. of Territories, volume IX, page XXXV.

The Extent of Its Exposure.—This formation whose presence may be detected often by the sandy soil and occasionally reddish concretions caps the table lands between the Cheyenne and Moreau Rivers from about 15 to 60 miles of Cheyenne Agency and with a width of 15 or 20 miles; also the table between the Moreau and Grand River from 15 to 35 miles west of Evarts, and with a width of 15 or 20 miles. It also caps the uplands north of the Grand River, and extends up that stream to the mouth of Black Horse Butte Creek, and up the different branches correspondingly. It extends up the Moreau to within 4 miles of the mouth of Flint Rock Creek, and up Thunder Butte Creek and other tributaries similarly.

It lies between the Pierre and Laramie high up on the south margin of the table land north of the Cheyenne River, and extends westward indefinitely. It seems to disappear or to lose its sandy character, as it has not been recognized in Butte County south of Deer's Ears and Short Pine Hills. (See Bulletin 2, S. D. G. S., page 47.)

South of the Cheyenne River and east of Manila the upper fossiliferous concretions of the Pierre are abundant, but none of them characteristic Fox Hills. The altitude of observed junctions of the Fox Hills and Laramie as indicated by the passage to brackish water life is as follows:

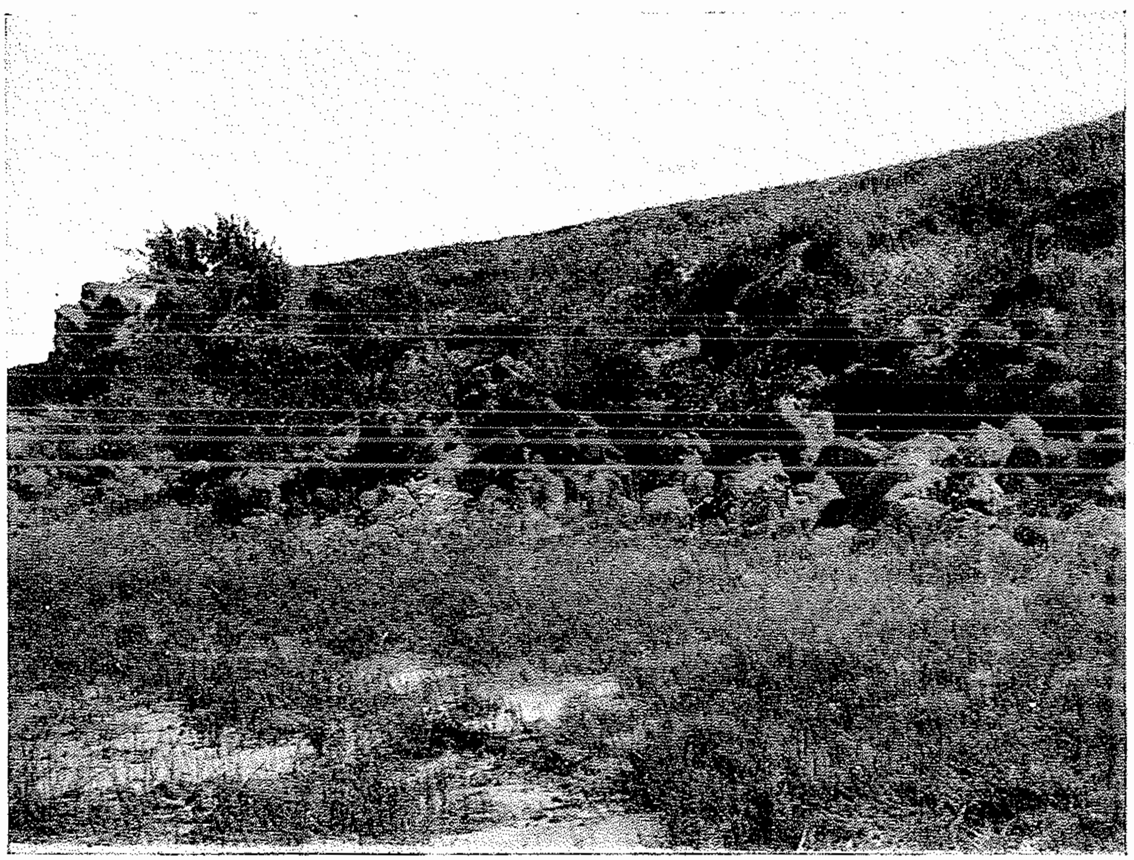
1.	Near the mouth of Black Horse Creek	2120	A. T.
2.	Meadow Creek near Grand River	2120	A. T.
3.	Cottonwood Creek	2150	A. T.
4.	Near mouth of Dirt Lodge Creek	2100+	A. T.
5.	Spring Creek	2122	A. T.
6.	Elk Butte	2070	A. T.
7.	On Fire Steel (Willis)	2085	A. T.
8.	Below mouth of Flint Rock	2200	A. T.
9.	Four miles northwest of mouth of Green Grass..	2350(?)	A. T.

In 1, 2 and 3 the marine shells *Lunatia, Dentalium, Volsella* and *Mactra* are found in clay below *Ostrea, Melampus*, etc., in a sandy shale, apparently above a sandy stratum which, however, is not so clearly demonstrated as would be desirable. In 4, 5, 6 and 7 the transition seems to be in the upper part of a thick sand stratum evidently coming in below the clays just

Plate 14.

A. Elm Water holes, showing topography near base of Fox Hills formation, flat tops of ridges caused by concretions.

Plate 15.



B. Concretions in the Laramie forming a revetment on shore of Soda Lake.

mentioned above. In 8 and 9 it is in sandy shale below a sandstone, which has marks of vegetation, and appears to be Laramie. Their highest marine fossils are *Naulitus, DeKayi, Scaphites*, etc. It would seem that in the same body of water it might be brackish in channels, while the outer sea was salt, and that the Fox Hills may be a shore or shallow water modification of the Pierre.

Origin of Fossiliferous Concretions.—The origin of the fossiliferous concretions has not been fully explained. They are subglobular and lenticular in form. In some layers the concretions are barren like those of the Pierre, and only trial will show whether they contain fossils or not. Very commonly they are crowded with fossils, which in the same concretions are usually only one or two species as though they had been isolated colonies in the surrounding mud flat. Some of the shallow masses are barely covered with the calcareous rock. In other cases they are very thickly invested. The colony theory seems as probable as any, but why should they have a thickness nearly equal to their breadth? No shells are found in the surrounding clay or sand. The shells do not seem to be horizontally laid as in stratified rocks. Is it possible that some strong currents broke them out of stratified patches and rolled them away? This does not seem likely when we remember the fine character of the material in which they lie; nor does it agree with the uniformity of individuals in the same concretion; nor with the difference of kinds in different concretions. That they have grown by concretion is evident, but the original blocking out and dispersion is the puzzle.

For list of fossils see Appendix A.

Effect on Topography.—A sandy, stratum overlying clay tends to protect by preventing surface wash, the water sinking into the sand. This, when it meets the clay, works to the surface on the side of the hill and produces springs. These quicken erosion at certain points and produce ravines that cut back rapidly and soon ridges appear, (Plate 14), from which ere long are cut more or less isolated buttes. The slipping of the clay and the washing out of the sand causes these to slowly melt away, though they may often last some time. If, however, the sand is held by concretions, the capping stratum keeps its shape much longer. Besides, as the butte is narrow the concretions and their fragments forms a revetment of the slopes, which makes them very enduring. The gentle undulating table lands between the Grand, Moreau and Cheyenne Rivers are due to this formation. The divide south of the Cheyenne which is composed entirely of the Pierre formation shows no table land, but a very uneven and much ravined ridge. The many buttes also studding the sides of the valleys of the lower Moreau are to be referred to the presence of the Fox Hills. The different layers of concretions being marked by the different heights of the buttes.

Since the upper part of the formation is sandy, it is affected to such an extent by the winds that extensive shallow basins are formed on the uplands. These afford rich meadows in many cases, and in others quite extensive open lakelets.

The economic effects of the formation of soils, distribution of water, etc., will be considered under their proper heads.

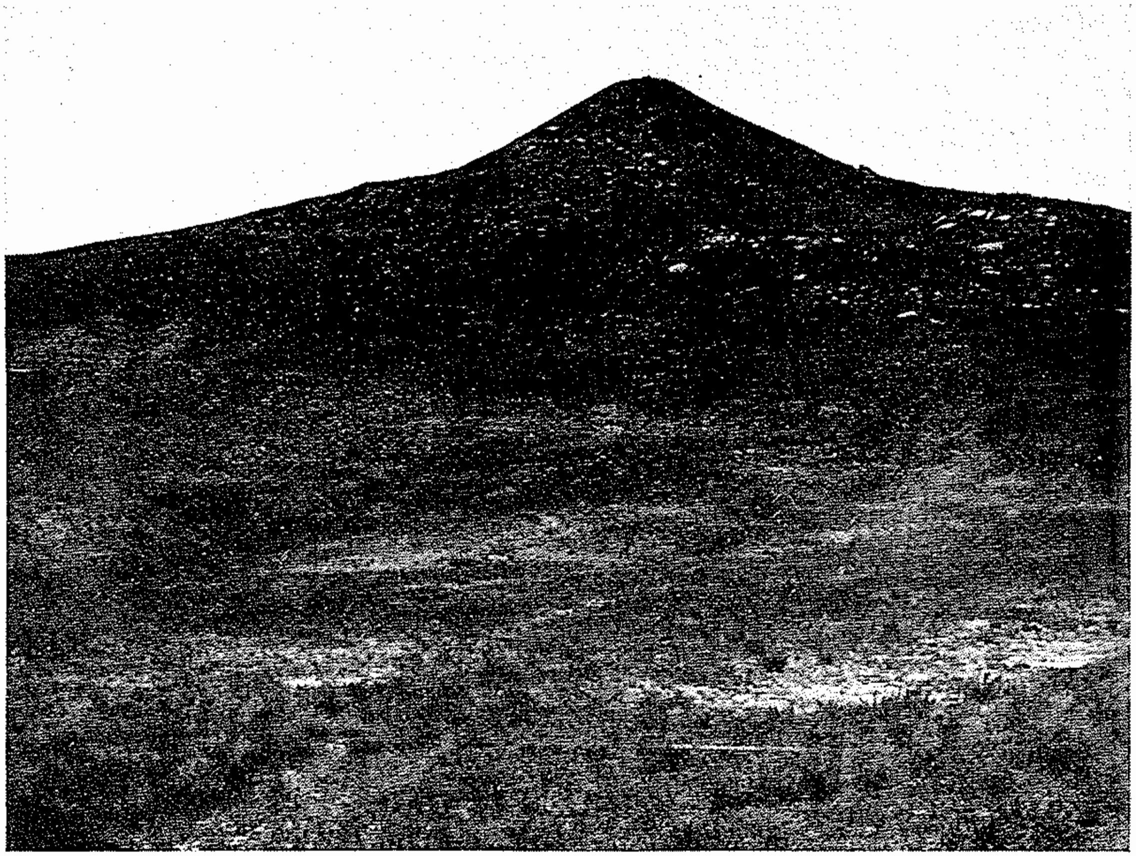
THE LARAMIE FORMATION.

Character and Thickness.—This is a very thick and extensive formation which is shown by its fossils to be of fresh water origin. It is composed of clays, loams, sands and sandstones with lignite and iron ore beds. None of them very thick, especially the consolidated forms and all varying much horizontally in quite short distances.

As one studies the region he will be constantly impressed with similarity of strata, not only in their composition, but in their order of succession. He may at first think that a sandstone stratum is probably the equivalent of a similar one he has noticed elsewhere, and the lignite stratum to be equivalent to the one there. He very often, probably more frequently than otherwise, will find that he has been mistaken. Yet certain very general groupings of strata may be outlined, though further study may modify such conclusions greatly.

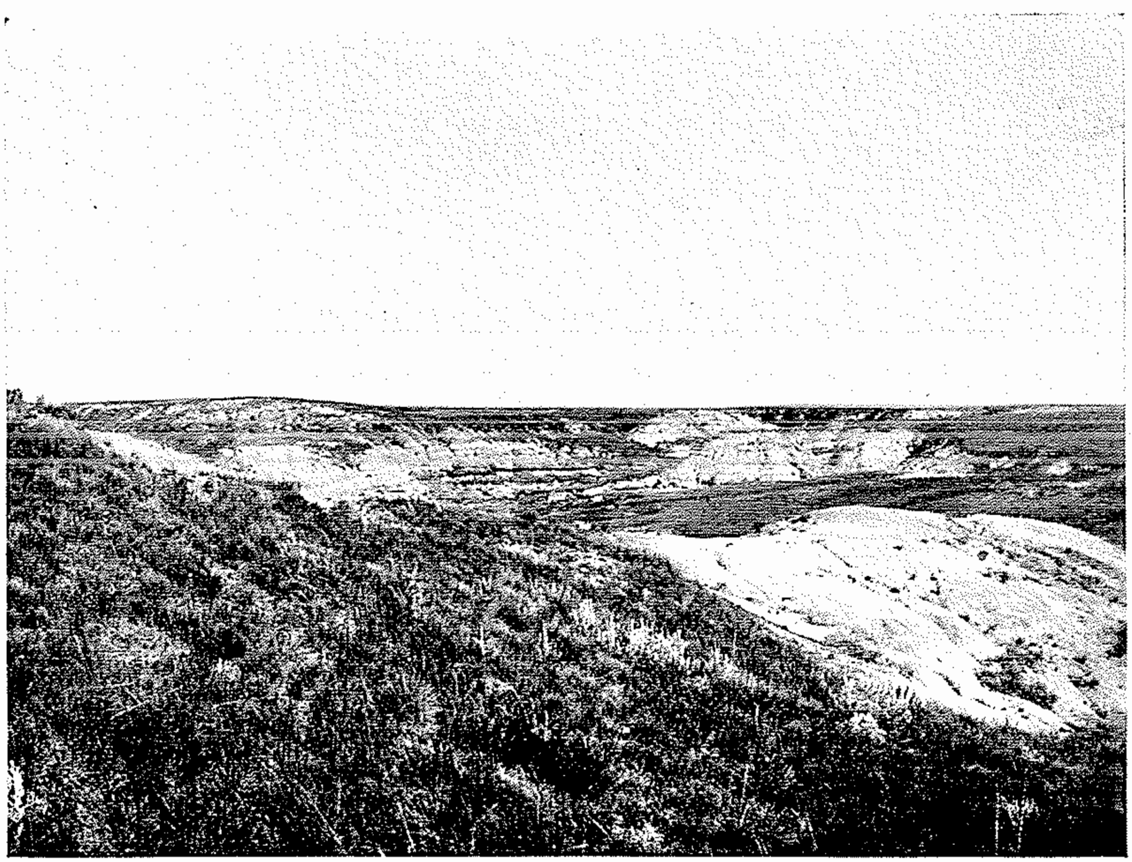
The clays are usually of a light or dark-gray, weathering yellowish. They sometimes resemble very closely those of the Pierre, or more frequently sandy forms of the Fox Hills. The sandstones and sands are usually gray, but are rarely very pure

Plate 18.



B. Rabbit Butte from northeast, Oligocene flint blocks on surface.

Plate 19.



A. West flank of Arrow Head Hills from the east, Laramie clays.

and usually grade insensibly into loams often closely resembling loess. The sands, loams and loamy clays often contain concretions, varying in size from a few inches up to 15 or 20 feet in diameter. They are usually lenticular in shaly material, and globular or sometimes curiously elongated in the sands and loams. The last form seems more prominent toward the west and in higher strata.

The lignite beds were nowhere observed to be over 4 feet in thickness except in the Slim Buttes; there they were found 8 feet thick. The lignite beds are more numerous and thicker toward the northwest. The lignite often shades into carbonaceous shale both vertically and laterally. In other words, it is usually in small patches, so that finding a thickness of several feet in one locality, affords no strong probability of its being found at the same level forty rods away. This will be discussed more fully under economic geology.

An exact representation of strata at any one locality, therefore, has nowhere near the value which it would have in the older rocks like the Carboniferous in the Eastern states.

It has seemed that the sandy strata because of their usually greater thickness and therefore greater horizontal persistence, their frequent local solidification into the strata which stand out prominently in the tops of masses and buttes, afford more promising horizons for correlation. Following this suggestion, which we acknowledge further research may show to be faulty, we may arrange the strata as we know them as follows:

It seems probable that the highest strata of the Laramie in the State are capping the Cave Hills.

GENERAL SECTION OF LARAMIE AND FOX HILLS.

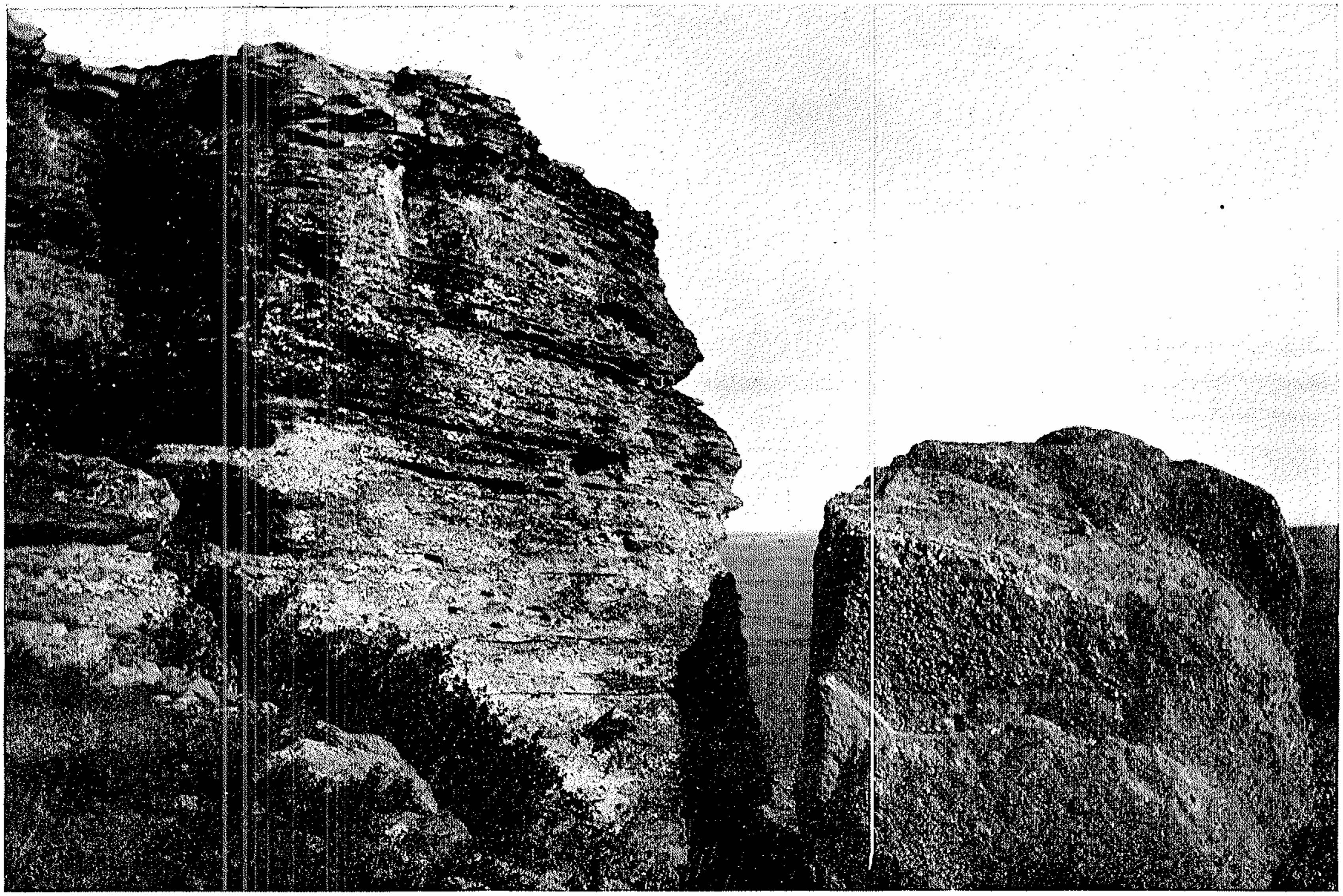
		Thickness—Feet.
A.	Sand and sandstone thinning toward the southeast in part due to early Tertiary erosion....	120
B.	Drab plastic clays mostly with layers of lignite, one fairly good and thick toward the top, one unimportant stratum of loam and sand shown in Cave Hills, about 85 feet of it in the southeast Slim Buttes	85 to 135

C.	Yellow sand and loam and sandstone Slim Buttes, 54 ft., Rabbit Butte, 75 ft., Bixby Hills less, a layer of lignite toward the bottom......	50 to 75
D.	Clay and unimportant layers of loam and sand.	100 to 120
E.	Sandstone and sand showing in Rabbit Butte and northeast 25 feet, and capping Thunder Butte and mesas south of Coal Springs	25 to 265
F.	Clays and loams	65 to 100
G.	Sands, sandstone and loam above Coal Springs and in the top of Black Horse Butte	65 to 80
H.	Clays, shaly and plastic with lignite frequently developed, on Cottonwood Creek with a rather important layer of sand near the middle, the whole being very irregular in stratification, and little of it consolidated, because of this there is much erosion in Schnasse County on both Grand and Moreau Rivers. Arrow Head Hills probably correspond to this, with *Unio Physa, Planorbis* etc.	300 to 350
I.	Sands with concretions and some layers of lignite showing along Grand River near the crossing of Bismarck and Deadwood trail, and on the Moreau below the mouth of Flint Rock Creek and toward the east usually form the capping of the Buttes in Boreman and Dewey Counties. Numerous fossils appear in patches, as e. g. at Dog Butte containing *Ostrea, Corbicula, Melania, Neritina, etc.*	

With this closes the Laramie, except that in certain places Laramie fossils appear in the upper part of the next stratum, which usually shows marine fossils in its lower portion.

J. Sand and clay interstratified in thin layers appearing on Grand River near the mouth of Black Horse Creek, and on the Moreau 3 or 4 miles below the Flint Rock with brackish water fossils in the upper layers, such as *Corbicula, Ostrea, Melampus, Volsella.* Below appear *Natica, Den-*

Plate 20.



Near view of S. W. angle of cap of Dog Butte, from N. W., strata perpendicular on the right.

	talium, Mactra, Scaphites. These appear at the points marked upon the map on the Grand River and Moreau River as the limit of the Fox Hills..	60 to 75
K.	Yellow sandstone, much of it massive, some of it quite hard near the top, containing *Tancredia, Calista*, *Fusus,* etc., coming in on Grand River a little above the mouth of Dirt Lodge Creek, producing cliffs more or less from that point tc Bull Head	50 to 115
L.	Stratified sandy clays with several levels of concretions lenticular and globular, many very fossiliferous, though some are barren; nearly always with a cracked interior	100 to 160

The lower part of the last stratum of the Fox Hills shades often quite imperceptibly into the dark plastic clay of the Pierre.

From this general discussion we estimate that the thickness of the Laramie is from 850 to 1,250 feet.

The junction of Laramie and Fox Hills is in J in some cases and elsewhere between J and K.

Altitude of the Formation.—From the known distribution of the Laramie we judge that its base rises toward the West, and that it dips somewhat toward the north. It is estimated that its junction with the Fox Hills is 2,350 A. T. north of Green Grass Creek, 2,120 near Little Eagle, 2,120 near the mouth of Black Horse Creek, but is about 3,000 A. T. on Sulphur Creek south of Deer's Ears a little beyond the western limits of our area. The southwestern portion of our area has not been examined, and therefore we are not prepared to speak intelligently concerning it.

There are no marked faults, except a few hastily inspected near Arrow Head Hills and east of the Black Horse Butte. They seem to be no greater than might be explained by inqualities in the original deposition of the material, or by strains resulting from dessication or settling. Small faults with a throw of 5 or 6 feet or less were noted at 2 or 3 points, but no opportunity was found for careful study of them, and their trival character seemed scarcely to justify much effort.

Effect on Topography.—As already noted, the Laramie resembles the Fox Hills in its containing strata of sand and sandstone interstratified with clay, and also in the prominence of concretions at different horizons. Plates 15, 16, 17, 18 and 19. There seems to be all gradations of stratification from remote and isolated concretions to those merging into one another, and in other places to extensive layers of sandstone. Fig. 15. Consequently, the easy erosion of the clays and unconsolidated sands, eventually brings out the patches of concretions and of sandstone as capping for buttes and mesas the latter sometimes several miles in extènt. Reference has been made briefly to this under the general subject of topography.

Fossils.—Comparatively few fossils are found in the Laramie, though the lignite beds are attended more or less with leaf impression and petrified wood. The former are reported to be very abundant in some localities, but in our examination we found but one or two points where they were shown. The latter was found quite frequently along Grend River near the Meadow Creek and Cottonwood Creek, and was reported from several other points. It usually appears black on a fresh surface, but weathers white.

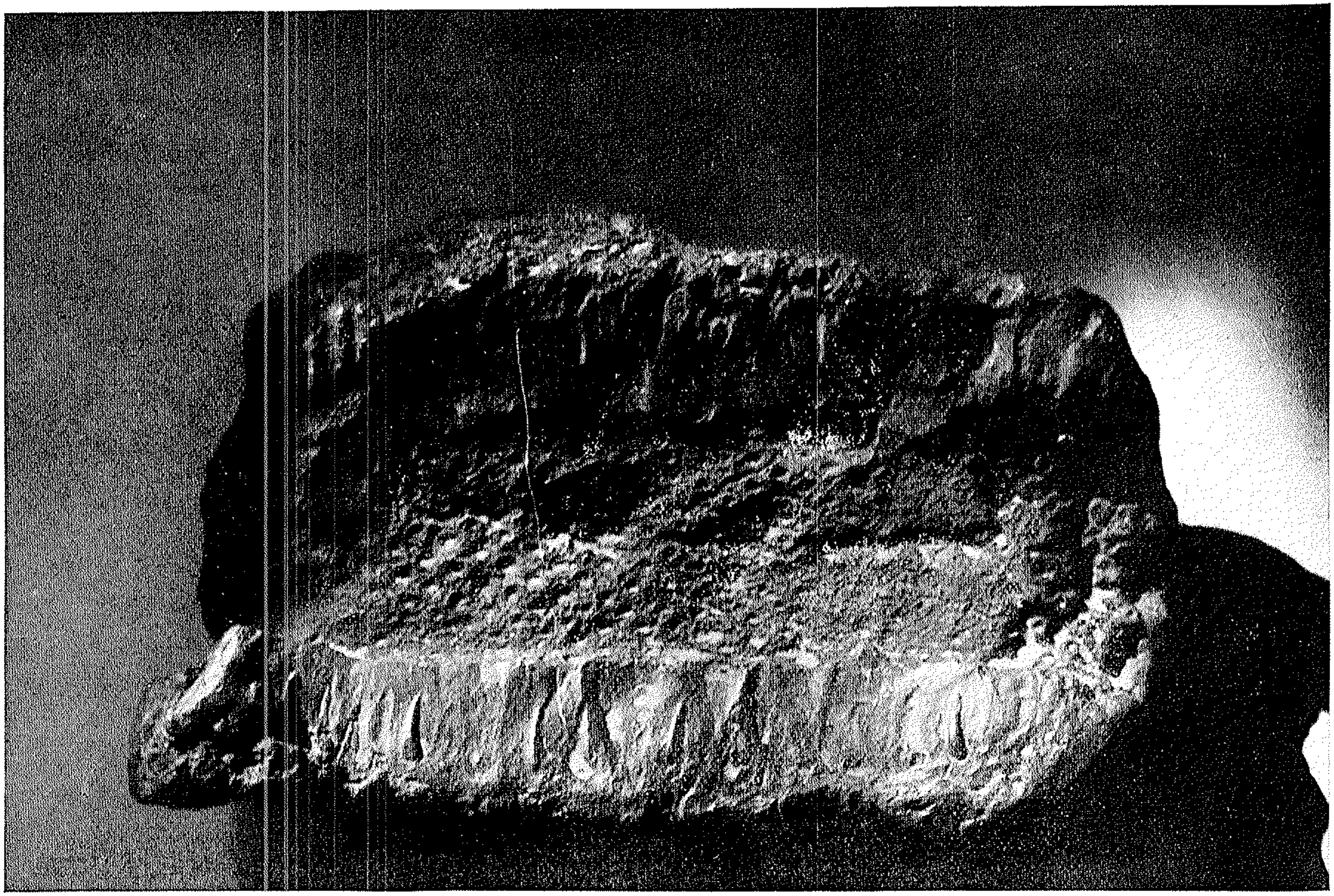
A fossil fruit of cylindrical shape resembling in structure Osage orange was found near Cottonwood Creek, Plate 22. In layers of limonite east of the Cottonwood, numerous casts of *unios* are found well preserved. Near Thunder Butte numerous oyster shells were found in bars along the Creek. The original stratum was not located. At Dog Butte on the trial west from Evarts and two or three miles west of Soda Lake, a stratum crowded with oysters, Corbiculas and other brackish water shells were found 25 to 30 feet in thickness, and about 100 feet above the general plain. Plates 20 and 21. These fossils are probably to be referred to near the lowest stratum of the Laramie. Apparently below this, and in the same lithological division as the Fox Hills, *Corbiculas, Volsellas,* etc., were found on Grand River at the mouth of Black Horse Creek, and on Willow Creek little east.

As a whole, the formation is quite barren of fossils. High up in the formation near the top of the Arrow Head Hills is a pond or lacustrine fauna preserved in flint modules. Samples of this were found not only at Arrow Head Hills, but near where

Plate 21.

***B.* Nearer view of part of last, shows oyster bed.**

Plate 22.



A Fossil Fruit from the Laramie, Grand River near mouth of Cottonwood Creek.

the Bismarck and Deadwood trail crosses Rabbit Creek. It seems probable from the topography and arrangement of streams that the rough country southwest of Arrow Head Hills along Flint and Deep Creeks may be due to a thickening of this flinty stratum.

Vertebrate fossils occur at several localities with some profusion. Those found were mainly fragments of a huge species of land lizards called Triceratops. Only one fairly complete bone of characteristic form was found. This was a scapula. Plate 23. It is over three feet in length. Many horn cores, fragments of long bones, and more or less perfect vertebrae were found on Cottonwood Creek and Dirt Lodge Creek in northern Schnasse County. Attention was kindly called to the latter locality by Mr. U. S. Gregg, who surveyed the region. The slipping of the clay beds had crushed them into irregular and oftentimes widely scattered fragments. Careful examination would probably furnish good specimens.

For list of fossils collected see Appendix A.

Tertiary Group.

Following the deposition of the Laramie when the region was probably near the sea level, there was an elevation probably greater toward the Rocky Mountain axis which tilted the lands somewhat as present, though in less degree.

During the Eocene little deposition if any, took place in our area. But on the contrary the surface was probably much eroded or cut away by streams.

During the Oligocene in the vicinity of Slim Buttes probably in a sluggish river valley, extensive deposits of marls and clays took place. It seems to have been a time of volcanic disadjacent extending irregularly and indefinitely toward the east. Buttes, as is shown by the highly tilted strata near the north end.* While these deposits were made in that portion, there seems to have been a chemical deposition of flint in the marshes adjacent extending irregularly and indefinitely toward the east. We have trace of this stratum, which is rarely more than a foot or two in thickness in the south end of the Slim Buttes within our area. That this was deposited in a marsh seems ap-

*S. D. G. S. Bulletin 2, p. 62.

parent, from the frequent casts of stems and branches of shrubs as though this flint formed around them while in their natural position, the same as may now be observed in the silicious waters of the National Park, in Wyoming. The only place where this flint stratum has been found in position is on the top of Cave Hills, but blocks of it are scattered very generally over the whole area, sometimes in great numbers as along Thunder Butte Creek, and sometimes with considerable size, 3 or 4 feet across, as near Rabbit Butte. Such as are found scattered upon the top of Rabbit Butte indicate that their original location was several feet higher, and that they have been let down by undermining.

During the Miocene, extensive deposits of marl, thin freshwater limestone and white sandstone were made in the vicinity of Slim Buttes, where they are now found capping the buttes. How far east such beds extend cannot now be determined.

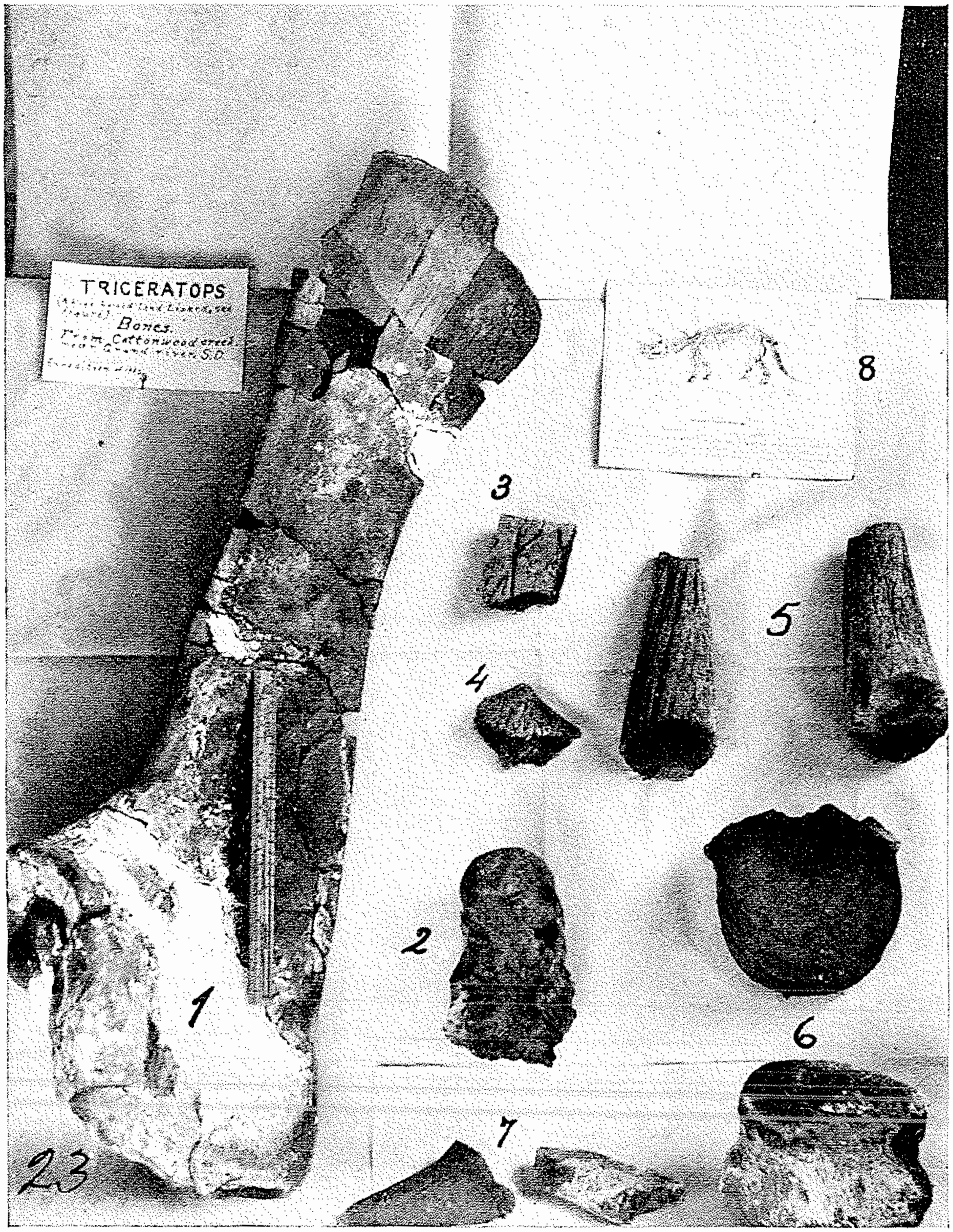
A section of the southeast corner of Slim Buttes is here copied from Bulletin Number 2. The writer did not himself visit the locality on this trip. For this and other sections see Appendix B.

During the later Tertiary the western elevation became so great that the streams cut deeper channels and did much of the work of removing the great mass of strata of which the high buttes like Rabbit Butte, Thunder Butte, etc., are but the meagre remnants. These have been left because of some advantage of location or consolidation of rock which offered more resistance than was found around them.

This took place in the last of the Tertiary, the Pliocene, and to this age we may refer the gravels capping Standing Butte southwest of Fort Bennet. In other words, that is the last remnant of the bed of the Cheyenne River at that time. The rapid erosion of the Pierre clays is made very impressive by this fact.

Quartenary Deposits.

Under this heading are included a great variety of surface deposits which are commonly called drift, because the materials composing them show that they have been brought from elsewhere. Some deposits may not, however, show their foreign origin



TRECEVATOPS Bones from Cottonwood Creek. 1, Left Scapula. 2, Oceipital Condyle and base of Skull. 3 and 7, Pieces of Neck Shield. 4, Marginal point of the same. 5, Horn-cores. 6, Vevtelvae. 8, Sketch.

clearly because of their fineness. Under this head all

(1) Glacial drift including scattered bowlders, moraines, till, etc., which may be the direct work of glaciers.

(2) Bowlder margins or elevated beached ridges and scattered blocks distributed by ice floating in glacial lakes.

(3) River terraces which were formed during the ice age.

(4) Silt deposits, some probably of aqueous deposition, and others deposited by winds.

Glacial Drift.—This is found only along the eastern margin of our area, east of the Missouri River. We shall speak very briefly, as the general treatment has been given in our Bulletin No. 1 and Bulletin No. 144, U. S. G. S.

No boulder clay or till is found west of the Missouri, for the Missouri found its present course around the edge of the ice, and true till of boulder clay is formed under glacial ice, usually without the action of water.

Moraines, which are ridges of till, and gravel, which accumulated along the edge of the ice sheet where it stood for a time, are found just east of the Missouri; e. g., the high ridge from La Grace to the mouth of the Blue Blanket, and similar high points 8 or 10 miles south of Bangor. Also some hills near Gettysburg, the Artichoke Buttes, Sully Buttes, some high land southeast of Fielder and Snake Butte north of Pierre. The first group were deposited by a tongue of ice pushing up the old valley of Grand River, which it had formerly occupied with the Moreau as its branch as far east as to the James Valley. The second group were formed by a lobe of ice pushing up in a similar way the old valley of Cheyenne and Bad Rivers. These ridges are not formed entirely of glacial accumulation, but of glacial till plastered over ridges of Cretaceous clays, mostly of the Pierre formation, though patches of Fox Hills and Laramie may perhaps be found toward the north.

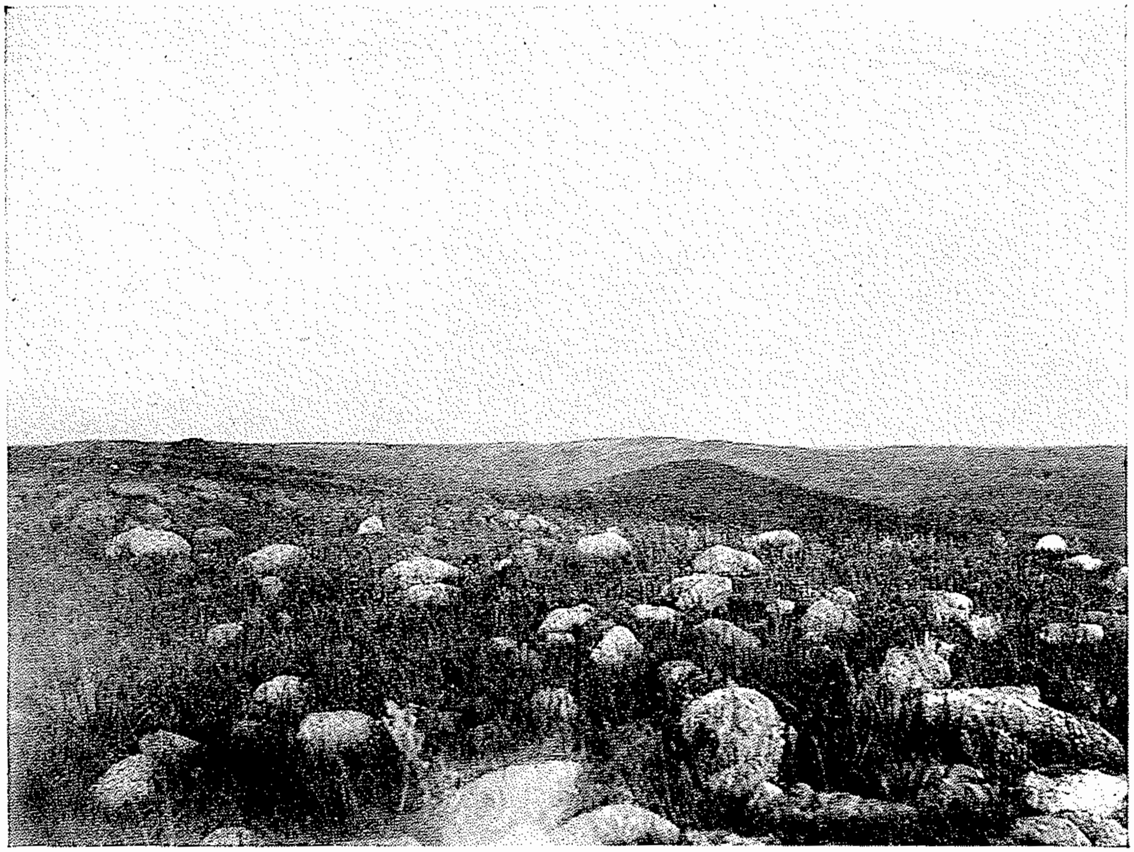
They were all formed at the same stage of the ice occupation, which was the early part of what is known as the Wisconsin Stage, or possibility of the Iowan sSage which preceded.

Boulder Margins and Scattered Boulders of Lake Arikaree.—When the ice sheet dammed up the Grand River and other streams, the Cannon Ball, Heart, etc., by preventing their flow in the James River valley their waters accumulated into lakes. These gradually overflowed the divides between, till they drained to the south along the line of the present Missouri River. Fox ridge then extending east of the Missouri River, being a high and broad divide, was one of the last to be cut through. Before then, and apparently as late as the formation of the first Altamont moraine already mentioned, there was a sheet of water extending northward from the north side of that ridge 25 or 30 miles wide, which has been named Lake Arikaree, from the Indian tribe which formerly occupied that region. So much has been fairly well established, though the details have not yet been worked out.

At least three outlets have been found, which were occupied possibly at somewhat different times and certainly for greatly different lengths of time; one crossing S. 32, T. 121, N. R. 76 W. north of Pembroke at an altitude of about 1,950 feet A. T., another, the Missouri, which is so eroded that all traces of its earlier condition have been removed, and a third, found on this expedition, down Stone Creek about 10 miles west of Cheyenne River Agency. This was evidently occupied for some time, as its bottoms and sides are well lined with large boulders. Its present bottom, however, probably marks a stage sometime after its first occupation. The more rapid cutting down of the Missouri apparently caused its abandonment quite suddenly, and we now have nearly the original form ravined by the cutting out of the Pierre clay below. It is 1½ to 2 miles wide. Its bottom is apparently quite flat, and its sides sloping generally at a steep angle. The bottom as nearly as has been determined by a barometer, is about 2,000 feet A. T. The high land between it and the Missouri is nearly or quite driftless. As will be seen further on, it is 100 feet or so lower than the boulder margins further west. This presents a difficulty which may possibly be explained by its being occupied for some time after those boulder strips had been formed. The scattering of boulders over point east of the Missouri, considerable higher than the bottoms of these outlets, may be explained in a similar way.

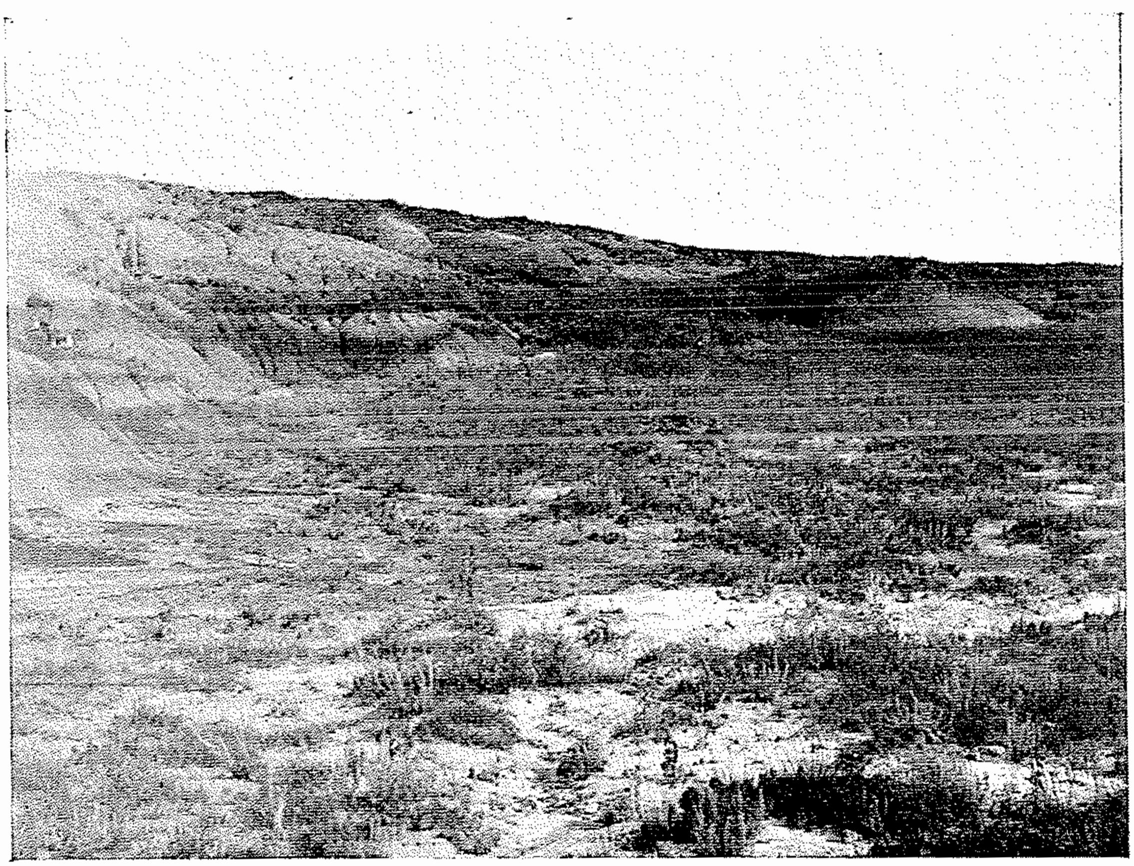
In Lake Arikaree there seems to have been more or less floating ice, at least in its earliest occupation. This we may

Plate 24.



A. Boulder Margin looking south of east high points little to right of center the same well developed

Plate 27.



B. Laramie Lignite beds sec. 13, T. 20 N. R 20 E, a small fault to the right of the boys, one bed 2 1-2 feet thick.

presume came largely from the glacier on the east, as the marginal moraine has a gap from Blue Blanket to Swan Lake Creek. Icebergs, from the edge of the glacier, presumably carried more or less of the boulders upon them, and still other boulders were very likely brought in spring by floating ice from farther north. The northern end of Lake Arikaree has not yet been determined. By some such action we may explain the sprinkling of granite and other northern boulders over the area which is outlined on the map as drift covered outside of the moraine.

Another feature referred to the same cause, are the boulder ridges that mark the margin of the drift, particularly along the north side of Fox ridge. They are very unique flat top ridges. They are not unlike other elongated buttes, except that they are nearly continuous in a sinuous line, and rise to the same level, and their tops are thickly strong with northern boulders. The accompanying views describe them better than words, Plates 24 and 25.

That the boulders are not the cause of the boulder ridges is shown by the fact that some buttes are found in the region without boulders, the concretionary strata of the Fox Hills being the more general cause. But the relation of a longitudinal system at the same level, while the surrounding surface was not so preserved seems rationally ascribed to the location of a strip of boulders along the line of the boulder ridges, which with the concretions resisted erosion sufficiently to preserve it as a ridge of greater or less height according to the amount of adjacent erosion in each case. The formation of a boulder strip of this sort can be easily conceived to have been begun by the stranding of ice blocks, laden with boulders along the shore of Lake Arikaree.

Such a boulder ridge margin is most distinctly marked from between Stone and Virgin Creeks near the southwest corner of T. 14 N., R. 29 E., and extending west northwest about 12 miles into the northwest corner of T. 14 N., R. 27 E. It lies on the north slope of the table land forming a divide south of the Moreau. The system is cut by Virgin Creek and by the next creek west, and has been cut into shorter ridges by several ravines. The larger branches of Virgin Creek and creek west have cut away the clays south of the ridge to the depth of 50 or 80 feet below their tops. The south side slopes quite abruptly, the north is gently sloping. No northern boulders are found outside of the line of boulder ridges, except where recent drainage may have readily carried them.

The height of these ridges, which to the eye seems horizontal, is about 2,150 feet A. T. as near as could be determined by a barometer at a rather unfavorable time. This seems at first to be too high to be harmonized with the level of the outlet already described. It may be that more accurate measurements will bring them nearer together. Another objection is that it is higher yet above the eastern outlet, noted as being found east of the Missouri. Probably there has been a westward rise of the land since the lake. A third objection to the above explanation of the boulder ridges, is the occurrence of some points higher than and within this margin and yet strewn with northern boulders. Virgin Buttes are such an example, and possibly the Patched Skin Buttes, though the latter have not been visited. These may be harmonized possibly by more careful leveling, but as far as the present barometer evidence goes, they are higher. If really so, it is difficult to reconcile with the above explanation, unless they were exposed to breakers in the old lake, and the erratics may have been hurled to higher levels. Evidently, the Virgin and Patched Skin Buttes were islands rising abruptly from the deep waters of the lake.

We should not expect to find extension of this margin across the Moreau valley, and still less across the Grand, but looking for it on the divide between we find a low bouldry ridge at about the same altitude according to one series of barometer readings. It does not there stand out as a flat top ridge, but a distinct ridge rising 60 to 70 feet above the ground on the east, and about 40 feet higher than the valley next west of it. It resembles a morainic ridge in the distance, by its boulders and general outline. It, however, is composed of Laramie clays veneered with boulders. It was seen to extend several miles in a northerly direction. North of Grand River again, and west of Hump Creek, we find similar high points thickly covered with northern boulders about 2,190 A. T. The surrounding region is

Plate 26.

High Terrace of Cheyenne near mouth looking northeast from the Pierre which has been cut down 30-50 ft. lower since the formation of the terrace so much eroded that they have not retained a ridgelike form, nor is it certain that these points mark the extreme margin. Boulders were found a mile or two farther southwest at lower levels. They may have floated on higher up the Grand River or have been washed down from the outside of the original margin. The most western northern boulder on the Moreau which was noticed, was a little west of Red Water Creek. On the hypothesis of Lake Arikaree we should expect such boulders to be found farther west along the river valleys than upon the divides.

The dotted line upon the map marks the margin of the original lake upon the higher lands, and the distribution of drift boulders in the river valleys. No labored study on this subject has been attempted.

River Terraces.—We have already referred to the prominence of river terraces in the topography of the region. We have preserved their more detailed description to this section, as they belong mostly to the Quarternary. From our story of the origin of the Missouri River it will be readily seen that all terraces now found along it and its principal tributaries are more recent than Lake Arikaree. The only probable exception is the portion of a high terrace preserved in Standing Butte which may be Pliocene in age. The satisfactory determination of the time of its formation must wait for the finding of characteristic fossils.

As we are not prepared to map the terraces in this area, we will give tables of their altitudes above their respective streams as have been determined by barometric readings, and several points where we have observed them. The letters "R" and "L" stand respectively for the right and left sides of the stream.

TERRACES ALONG THE MISSOURI.

Locality.	Heights in Feet above the Stream.
La Grace L.	50, 200.
(Reigstadt) mouth of Grand River L.	50, 95, 150, 200, 335.
Evarts L.	22, 80, 110, 166, 210, 250 to 270, 378.
Le Beau L.	35, 54 to 65, 130, 240 to 260.
Forest City L.	20, 56, 75 to 100, 175, 240, 325 (?)
Fairbank, L.	10, 20, 40 to 50, 250, 250 to 270.
Fort Bennett, L.	270 to 280, 350. (?)
R.	200.
Fort Sully, L.	10 to 12, 50 to 65, 90 to 100, 165.
Oahe, L.	25, 85, 100 to 120; 300 to 360.
Pierre, L.	50, 70, 163, 200, 350.

TERRACES OF CHEYENNE RIVER

Locality.	Heights in Feet Above the Stream.
Near Smithville; mouth of Elk Creek	
L.	27, 240 to 250, 335.
R.	190 to 200, 240, 285, 335.
Near Leslie, L.	105, 200, 410.
R.	70, 200, 425 to 460.
Near Rosseau, L.	110 to 120.
R.	207 to 227, 342, 443 to 450.

TERRACES OF GRAND RIVER

Locality.	Heights in Feet above the Stream.
Deadwood and Bismarck trail, R...	10, 20 to 25, 45 to 54.
Mouth of Black Horse Creek, L....	10, 18, 65, 115 to 130, R. 130.
Mouth of Willow Creek, R.........	125 to 140, 300.
Mouth of Cottonwood, L...........	180; R. 40, 163 to 180, 243 to 250.
Mouth of Dirt Lodge Creek, L......	108 to 163, 210.
Mouth of Hump Creek, L..........	140, 175 to 110.
Spring Creek, L..................	90, 170, 210.
At Little Eagle, L................	135, 180, 200; R. 200.
Seven miles below Little Eagle, R..	18, 27 to 63, 135, 162.
Near mouth of Snake Creek, R.....	162, 210.

TERRACES OF THE MOREAU.

Locality.	Heights in Feet above the Stream.
Bixby, L	80; R. 12, 18.
Mouth of Rabbit Creek, L..........	12, 30 to 40, 110 to 130.
Near Rabbit Butte, L.............	72.
Deadwood and Bismarck trail, R....	90.
Mouth of Flint Rock, R...........	10, 27, 54, 108, 144 to 154.
Mouth of Green Grass, R..........	18, 45, 65 to 72, 125 to 145; L. 18, 45, 100.
Mouth of Little Moreau, R.........	15, 30 to 60, 117 to 144; L. 15, 180 to 207, 220.
White Horse Camp and below, R...	15 to 23, 50; L. 20, 25, 108, 240.

Terraces along the Missouri over 100 feet in height are usually heavily charged with northern boulders, granite, limestone, etc., and doubtless marked stages of the River during the presence of glaciers in the region not far away. It was probably a time of great rainfall and of flooded streams. Those from the west gathering the rainfall only, and those from the east swollen from the melting ice, particularly in the summer. Not only would boulders be rolled along by the vigorous currents, but, in the spring especially, many would be floated by adhering ice.

Moreover, as we have seen, the channel of the Missouri had been recently outlined and was not yet worn down to an even grade. The glacial period was therefore the time of deepening this channel, and with it the channels of all its tributaries. Before the ice age, probably the western mountains were not as elevated as now, and the streams may have had gentler and longer slopes which reached to the James River valley. With the change of the Missouri and the cutting down of its channel, they were quickened and cut down more rapidly. Thus we have an easy explanation of the many and imposing high terraces of these streams, especially of the Missouri and the Cheyenne.

The terraces of the Missouri are often much wider than the present bottom land, but they do not compare with those of the Cheyenne, which are sometimes from 4 to 6 miles wide. All of these terraces are capped with alluvial deposits, sand, gravel and loam. They are quite even and generally easily tilled, and are fertile when sufficiently watered. The depth of the alluvium is from 10 to 25 feet or sometimes from 40 to 50. The lower part of the terrace and usually the most of it is composed of the common rock of the country. The Pierre yield more rapidly to erosion has often been cut down below the level of the adjacent terrace. See Fig. —

Terraces below a hundred feet are not so stony and are usually covered with a fine silt or clay. They are commonly called bottoms, because they resemble the common bottom lands, or present flood plains of the stream, and differ from it only ing being higher. Conversely, the common bottom or flood plain may be considered also as a silt terrace.

Loams or Silts.—We may discuss these deposits separately because of their prominence, their beneficial effects upon soils, and because of their problematic origin. As already stated, they are a prominent ingredient of the lower terraces, but they are also found capping the high bouldery terraces. Loam may be defined as a very fine clayey sand. It is often deposited by flooded streams as may be noted in any flood. Loam commonly shows only slight trace of stratification, because the material is so fine. Besides, it is often cut by vertical cracks or joints which causes it to carve into cliffs like massive stone An ancient silt found capping the hills along the Rhine was named "Loess" years ago, and that name has been widely applied to a similar deposit along the Mississippi, Missouri, and other streams. The typical loess is extensively distributed along those streams as far north as Iowa and Nebraska. Dr. Hayden sopke of it as being found as far up the Missouri as the Great Bend. He might with equal propriety have extended it 100 miles farther, for the high terraces from Pierre to Sully are capped with a deposit closely resembling the loess. In some places it is reported by well diggers to be then over 30 feet in depth.

The first thought is that this silt was deposited by the waters of the river in the higher floods after the coarser material had become comparatively stationery, either because the glaciers were less active or the current less vigorous. Yet some argue plausibly that this ancient silt is gradually accumulated dust blown from the rivers by the wind and lodged in the grass which grew more closely upon these terraces, and which also prevented its removal by the wind or by common erosion.

It is likely that both of these influences have had their part in the deposition of the loams in different localities or at different heights in the same locality. There is no doubt that the wind is an active agent in distributing a deposition of fine sand over the surrounding country

Economic Notes

In General.—No ores of any value were found, and none may be expected in this region, for the strata are all comparatively recent, unconsolidated, and have never been subject to volcanic disturbances or volcanic action, neither in or near them since their deposition. They are too remote from the Black Hills to have placer gold in paying quantities, and the only chance of finding any of the precious metals would be possibly in some occasional boulder from the gold-bearing rocks of Canada brought by the glaciers, or from the Black Hills brought by the river; and the finding of one specimen would be little or no sign of any more of the same kind.

Iron ore is found in small quantities, but not of any value. In the Laramie at several places thin layers of limonite and frequent concertions of clay-ironstone were found. Some specimens apparently quite rich, but no beds of size sufficient to warrant any attention.

Petroleum.—No petroleum was found; this was something of a disappointment, but some trace may eventually be found in the Pierre or in the Laramie. These are somewhat oil-bearing in Wyoming. Of course, in a réconnoissance, exhaustive search was not practicable, but as no trace or rumor of anything of the sort was met with, the chances are considerably against its presence in the area traversed.

Peat.—No peat was found, nor any locality promising it. The dryness of the region, the not infrequent occurrence of the prarie fires on the uplands, the rapid erosion of the slopes, the abundant deposition of sediment in streams, the recent cutting down of the main streams and the scarcity of copious springs, are all unfavorable to its accumulation.

Coal and Lignite.—Persistent reports of coal attested by good samples brought in by Indians prompted the U. S. G. S. to send out Mr. Bailey Willis with a party in 1884 to determine the location and value of such finds. He examined and mapped with Mr. F. J. Knight an irregular area between the Moreau and Grand Rivers covering about 2,000 square miles. His results were published very briefly as Bulletin 21, entitled "Lignites of the Great Sioux Reservation." The brief verdict may be summed up in the following quotations: "There is no other coal than lignite on the Reservation, and that is of poor quality;" "with the greatest thickness of two feet and four inches these beds possess no economical value." The best exposure of lignite which he found was on one of the head branches of Fire Steel Creek in the northwestern part of T. 17 N. R. 22 E. A careful section of the bed, he gives as follows:

	Feet.	Inches.
Roof, gray clay		2
Earthy lignite		3
Goog lignite	2	4
Earthy lignite		6
Footwall gray clay		

Three hundred feet to the right of the section a bed of nodules, iron carbonate, replace the lignite; 400 feet off on the other side it had deteriorated to a brown clay.

In one of his figured sections he gives a bed 4 feet in thickness, but is was probably impure, so that he did not consider it the most valuable bed. He made quite a careful examination of Fire Steel and Cottonwood Creeks which flow into Grand River.

For the same region our observations fully corroborated the conclusions as stated above, except that we would count beds of such thickness as he reported as of considerable local economical value. As our course included more, we may add that thicker beds and a better quality are found farther west, as was shown by our exploration of 1895, given in Bulletin 2 of the State Survey. And further shown on this trip by the finding of an eight-foot bed of lignite by Mr. Ellis in the southeast angle of Slim Buttes.

We found also at Coal Springs a fair quality of lignite exposed in the spring at Green's Ranch on the head of the south branch of Black Horse Creek in the southeast quarter of T. 18 N., R. 16 E. The same bed was found in a well a few rods away, and also at a neighboring ranch. Circumstances prevented our making a careful examination which would have been well. The section as seen was as follows.

SECTION OF COAL SPRINGS.

	Feet.	Inches.
Slope showing much sand with concretions and thin strata hardened into stone.........	100	
Good lignite	1	

Black shale		6-8
Good lignite breaking in blocks	3	
Shale	3	

The spring which has cut a deep narrow ravine issues directly over the lignite.

From a section which Willis gives in this vicinity it seems probable that this lignite becomes separated into two beds by 9 feet of shale between. The beds, however, are but 18-16 inches in thickness.*

At Rabbit Butte no beds were seen more than two or three inches in thickness, but one near the level of Rabbit Creek northwest of the Butte was reported to be 16 inches in thickness; and Willis gives a section still farther west showing about 8 feet of lignite out of 19 at an altitude of about 2,733 feet A. T. There were 4 beds 3 feet, 1 foot, 2 feet, and 2 feet in thickness.**

On Thunder Butte Creek 7 miles west of Bismarck and Deadwood trial, lignite has been locally obtained out of the bottom of the creek; how thick and how pure is not reported.

At Black Horse Butte a bed or two of impure lignite was found only a few inches in thickness. Willis reports two others 2 and 1½ feet in thickness about 70 feet below the top of the butte. Similar beds of impure lignite he found 50 to 100 feet above the Grand River north of the butte, and we noted 3 feet of black shale containing several inches of lignite a few feet above the river at the crossing of the Deadwood and Birmarck trail. Reports were given us on several beds on Black Horse Creek. Mr. U. S. Gregg reported several exposures along the east branch of Black Horse Creek between Townships 18 and 19, R. 20 E.; also beds 4 or 5 miles up the same creek. Quite definite reports of one about 10 miles up was given by another. It was said to be "20 feet thick." I sent Mr. Ellis with a party, and he found two exposures, one at 2 or 3 inches of good lignite in 12 feet of black shale, believed to be on south of Sec. 34, T. 19 N., R 19 E., and the other farther north, a similar mixture of black shale and lignite 5 to 6 feet thick. The beds farther up were not visited. This may be taken as a fair sample of the way in which casual observers are apt to exaggerate facts honestly enough, because the black shale

*U. S. G. S. Bulletin 21, Pl. III, Fig. 7.
**Ibid. Pl. I. Fig. 3.

is easily mistaken for coal at a short distance, and because when actual measurement is not taken, one is apt to make them large enough in giving good news. I have little doubt that the beds farther up the creek were quite as worthless. Opposite the mouth of Willow Creek on Sec. 13, T. 20 N., R. 20 E., a bed of fair lignite 2½ feet in thickness with fossil resin in it retaining its yellow color was found about 30 feet above Grand River. Fig. . On Cottonwood Creek 6 to 8 miles from Grand River on the east side, a bed was found 6 feet in thickness consisting of 2 feet of good lignite, 2 feet very impure, and 2 feet very fair. This bed extends for several rods varying much in quality within that distance. The roof and footwall are both of gray clay, and specimens of fossil wood and of bones of large reptiles were common in the vicinity. This was about 180 feet above Grand River.

Up Dirt Lodge Creek a 3 foot bed of black shale and lignite was found on Willow Creek estimated to be Sec. 21, T. 21 N., R. 21 E. It had been partly burned out so that it was marked not far away with a layer of brick-red clay.

Mr. Kippax of the Surveyor General's office, Huron, called my attention to report by Mr. ———, who surveyed the area, that lignite was found in several places in the northeastern part of T. 19 N., R. 21 E. with a thickness of 3 or 4 feet. Attention was also called to what was looked upon as volcanic scoria, which no doubt was clay fused by the burning of portions of the same. It is not unlikely that this corresponds to the bed reported by Willis on the head of the Fire Steel, but 20 miles farther south, and possibly to the beds less noted on Cottonwood Creek.

While at Little Eagle we learned that search for coal had been made in that vicinity by experts from North Dakota. The purpose was to discover, if possible, a supply of lignite for the Government school of that place, which hitherto had burned lignite brought by the Indians from the farther west, probably from the Fire Steel. The search was not successful. No beds of sufficient thickness were found to pay for working in that vicinity.

This comprises the evidence as far as yet accumulated which authorizes the statement made in the bi-annual report of the State Geologist for 1902, which is here reported with slight modification.

Along the northern line of the State, thin beds of lignite occur at several horizons probably as far east as Oak Creek, but the quantity of lignite gradually diminishes to the south and to the east. At all horizons or levels it is patchy, or developed in quite limited areas. In some cases where a bed of lignite 3 or 4 feet in thickness is found quite pure and easily worked, within a few rods it has been gradually reduced in thickness or has been replaced by shale, nodules of iron ore, or sand, as the case may be. Moreover, in many cases the beds have suffered from spontaneous combustion due to the exidation of iron pryrites which are often quite abundant. In this way the carbonaceous matter is entirely burned out, leaving clay burned to the color of brick or slag.

While particles of bright clean lignite are found scattered throughout the region occupied by the Laramie, yet no beds capable of being worked even for local use have been found farther south than the south end of Slim Buttes on the west, nor south of the line reaching from that point to the southeast corner of T. 17 N., R. 22 E., nor east of the line reaching from that point to where Oak Creek crosses the northern boundary of the State.

It would be rash to assert that no beds of lignite of value will be found outside of that limit, but it seems very improbable. Nor do we wish to have it understood that the area northwest of the line given is underlaid by valuable beds of lignite. In fact, as has already been stated the beds found are of comparatively little value. No beds over 5 feet of pure lignite are likely to be found much east of the west line of the area. Such beds have been found at several points in the Slim Buttes, and at more than one horizon. The same difficulty generally obtains here in this area as was noted in Bulletin 2 of the Survey in the beds farther west; viz., that there is rarely good roofs, the beds both above and below are generally clay.

Gas.—Nearly all of the important gas wells of this State have been opened in this area. Little can be added to that which is already published in Bulletin No. 3. The gas is dissolved in the water flowing down from the deep artesian wells, though at several points it appears before the water is struck, sometimes as high up as just below the boulder clay, as in wells around Blunt and north of Pierre. Yet, there seems to be no doubt that the mass of the gas is closely associated with the artesian water, and is perfectly dissolved in it until reduced pressure, as it comes to the surface, allows it to separate. Whether it is derived from the strata in which it appears, or whether it is generated elsewhere and is brought by water, has not been discovered. Also whether it may not escape upward through clays which are im-impervious to water has not been determined. The latter supposition might explain the striking of gas before the water as is done below the boulder clay and at some other horizons.

Perhaps the strangest thing connected with its distribution is its abundant appearance in the artesian waters of western Sully and Hughes Counties and yet its not showing in the same water strata in the eastern part of these counties. If the gas were not dissolved in the water, but were separated, we would think of it as remaining behind in the summit of an anticline as the waters move eastward, but such can hardly be the case when the gas is incorporated with the water. On the whole, the supposition which seems to agree best with known facts, is that as the water moves eastward very slowly, probably less than one mile a year, the gas may escape upward through the clay. Yet, the writer knows of no clear evidence of such escape unless it be the finding of deposits of gas in the sand under the boulder clay. Besides, it seems difficult to believe that the amount of gas, which appears in the Pierre and the Pearl Township wells, should escape in this way before reaching Hand County, where no clear evidence of gas has been found.

Is it possible that the waters move in some other direction? The hydraulic gradient seems not to indicate the fact. On the whole, the case presents a first-class problem which may lead to some important discovery, either concerning the distribution of the gas, or possibly to the origin of the same.

As is stated in Bulletin No. 2, it seems likely that the gas comes from carbonaceous matter either in the Dakota, or in the

Carboniferous lower down, connected with the Dakota by the artesian waters. Nearly all the wells marked upon the map and reaching along the whole eastern side of our area are gas-bearing, and it is reasonable to think that the gas area extends westward indefinitely perhaps under the whole area which we are considering. See profile 5.

As to its probable continuance we can only say that experience elsewhere warns us that natural gas supplies are readily exhausted. In West Virginia, Ohio and Pennsylvania the gas is free from water, and can therefore be exhausted more readily. I have been unable to learn of its being associated with water in any other locality; and it may be that farther west quantities may be found more independent of the water.

The separation of the gas from water for use is a problem which has not been solved to full satisfaction. As the water comes to the surface and the pressure is removed most of the gas flashes into bubbles, but it is thought that considerable may linger in the water. It is reasonable to believe that such is the case as long as there is pressure, and in the usual conditions of separation there is not only the atmospheric pressure, but that necessary to confine and distribute it. Some have recommended that the water be agitated to separate the gas. This will have little tendency to do so as long as the pressure remains. The gas in all cases is a colorless, odorless gas which is mainly composed of the chemical compound or called marsh gas.

Building Stone.—Glacial boulders are numerous along the Missouri River upon its terraces and over all the region east from it. They are mainly gray granites and white limestone. As they have been passed through the mill of glacial action they are all very durable and have the qualities both of strength and beauty which are usually associated with such rocks. With care, very attractive dimension stone may be cut from them, but on account of the difficulty of finding sizes sufficiently large, and kinds and numbers of the same kind together will probably be used only for rough work, such as foundations where they may be of much value. A sufficient number may also be found for practical purposes in some localities along the boulder margin of Lake Arikaree. Over most of the old lake bed they are too sparsely scattered.

The Pierre furnishes no stone satisfactory for building so far as has been observed; nor does the Fox Hills formation, except a thin rusty sandstone on Grand River near the Dirt Lodge Creek and Spring Creek. Also according to Willis up the Fire Steel. It is probable also that the stone in the buttes along and east of the Missouri River near La Grace belong to the same horizon. It may be found of value for foundations, but it is neither attractive nor durable stone.

In the Laramie, sand beds have been consolidated in several horizons into a compact durable stone of a pleasing gray color with strata of medium thickness and quite well adapted for common building purposes. It does not, however, usually afford blocks of sufficient size for dimension stone. Possibly a deeper excavation may show the beds of massive character. Localities where sandstone of some value was noticed was as follows.

At Thunder Butte the durability of the thick capping stone is evident. This shows also upon the mesas generally in eastern Butte County, Black Horse Butte, and the buttes along the Fire Steel. Some of the better quality of the Laramie sandstone was found at Twin Buttes north of the Little Moreau, and this srtatum is manifest in many of the buttes studding the country from that vicinity northeastward and southwestward, reaching beyond the Missouri River in one direction, and to Cherry Creek in the other. It cannot be assumed, however, that all buttes of that region contain this sandstone. In many of them the sand is not consolidated except in concretions.

Rabbit Butte, Arrow Hills, and the Buttes up Dirt Lodge Creek, and in northern Schanasse are generally without stone, except that around Rabbit Butte, where, as has already been stated, there are numerous large blocks of a yellowish flint.

Clays.—No testing of clays for brick making has been made, and we only remark that doubtless suitable material for brick making and pottery of different grades may be found in unlimited quantities in the Pierre, lower Fox Hills and in the clay strata of the Laramie. The loams of the Laramie and that capping the terraces may probably make good bricks, when care is taken to remove or to grind up lime nodules which frequently occur. Some of the underclays of the Laramie may possibly be used as fire clay, though none were found showing very close resemblance of the typical fire clays that are used elsewhere.

Cements.—We introduce this head here simply to say that the noted Roman cement, a kind of hydraulic cement, is made in England and elsewhere from septaria, similar in general appearance and structure to lenticular concretions found so abundantly in places in Pierre and Fox Hill formations. It is possible that some in our area may prove to be of value in this direction. They have the same general composition, namely, clay, lime and iron, whether the proportions are right,. or whether some quality is lacking, cannot be determined without testing. If it is found satisfactory, there are various places along the Moreau and Grand Rivers where large quantities have been collected by the stream.

Sand and Gravel.—The former is found quite common along the Cheyenne and Missouri Rivers; also on the uplands in connection with the Laramie strata and upper part of Fox Hills, but in general it lacks cleanness and sharpness. Perhaps the purest found was in the deep sand deposits of Coal Springs.

Gravel is less common, but it is found in the upper part of terraces, especially the higher ones along, and east of the Missouri River where the glacial drift has collected materials hard and durable. Large quantities have also been brought from the Black Hills, rocks, and deposited in similar localities along the Cheyenne River.

Soils.

Rarely do we find the geology of the region affecting soils more markedly than in the region under consideration. We might perhaps classify according to the kinds of soils; that is, we might divide the different soils into the kinds which are recognized as of world-wide extent, namely:

1. Clay or gumbo soils, where the grain is so fine that water does not circulate through it to any considerable extent, although it may be very largely absorbed near the surface. Such soils retain the water near the surface, and when drought comes,

part with it quite quickly, leaving the surface baked and cracked into clods.

2. Loamy soils, where the material is porous enough for the slow seepage of water and for efficient capillary action in time of drought, so that in time of drought the water which has been stored in the subsoil is returned to the surface gradually. Moreover, the soil is so lacking in tenacity that it is not easily hardened into clods.

3. Sandy and gravelly soils, where the size of the grain or the porosity is so great that water is readily absorbed and runs into the depths unless retained by a clay layer in the subsoil. And the pores are so large that capillary action does not readily bring the water back in time of drought. Perhaps this head should be subdivided according to the presence or absence of an impervious layer near enough the surface to prevent the water escaping so far near the surface as to be beyond the reach of ordinary vegetation, as the sandy soils have the advantage of preventing the evaporation like mulching, if the moisture can be obtained by some means near the surface, the circumstances are favorable for abundant vegetation. If, however, this impervious layer is lacking the sand can only be made productive by abundant rain fall. In time of drought it becomes a sandy desert.

4. Gravelly soils do not need to be distinguishel from sandy soils, except that there may be additional difficulty on account of the greater size of the grain, besides the absence of sufficient fine material for the nourishment of plants.

5. Stony soils. Under stony soils are included such as are so strewn with stone as to interfere with growth of vegetation and with their tillage. In this classification we have said nothing about the chemical composition, which may sometimes be a very important factor, but usually the physical features as indicated are more influential in the immediate efficiency of the soil. Instead of treating the soils under these heads we prefer to treat them under the several geological formations upon which they rest.

The Pierre Soils. The Pierre, with its remarkable uniform dark clay, becoming always more or less plastic by weathering and with large quantities of soluble salts known as "alkali," and with no gritty or sandy material in it, exercises a marked influence on all of its soils. Dr. Hayden early said, "Wherever it prevails it gives to the surface the aspect of desolation." In this he refers not only to its comparative barrenness, but to its dark color. He adds, "Although these clays seem to be so sterile, and in the dry season are typical of extreme aridity, yet they are by no means destitute of vegetation. The various species of chenopodiaceous shrubs and herbs that are peculiar to the West find their natural habitat in these clays and grow more luxuriantly. It is probable that the country underlayed by rocks of this group will prove fertile and can be irrigated."*

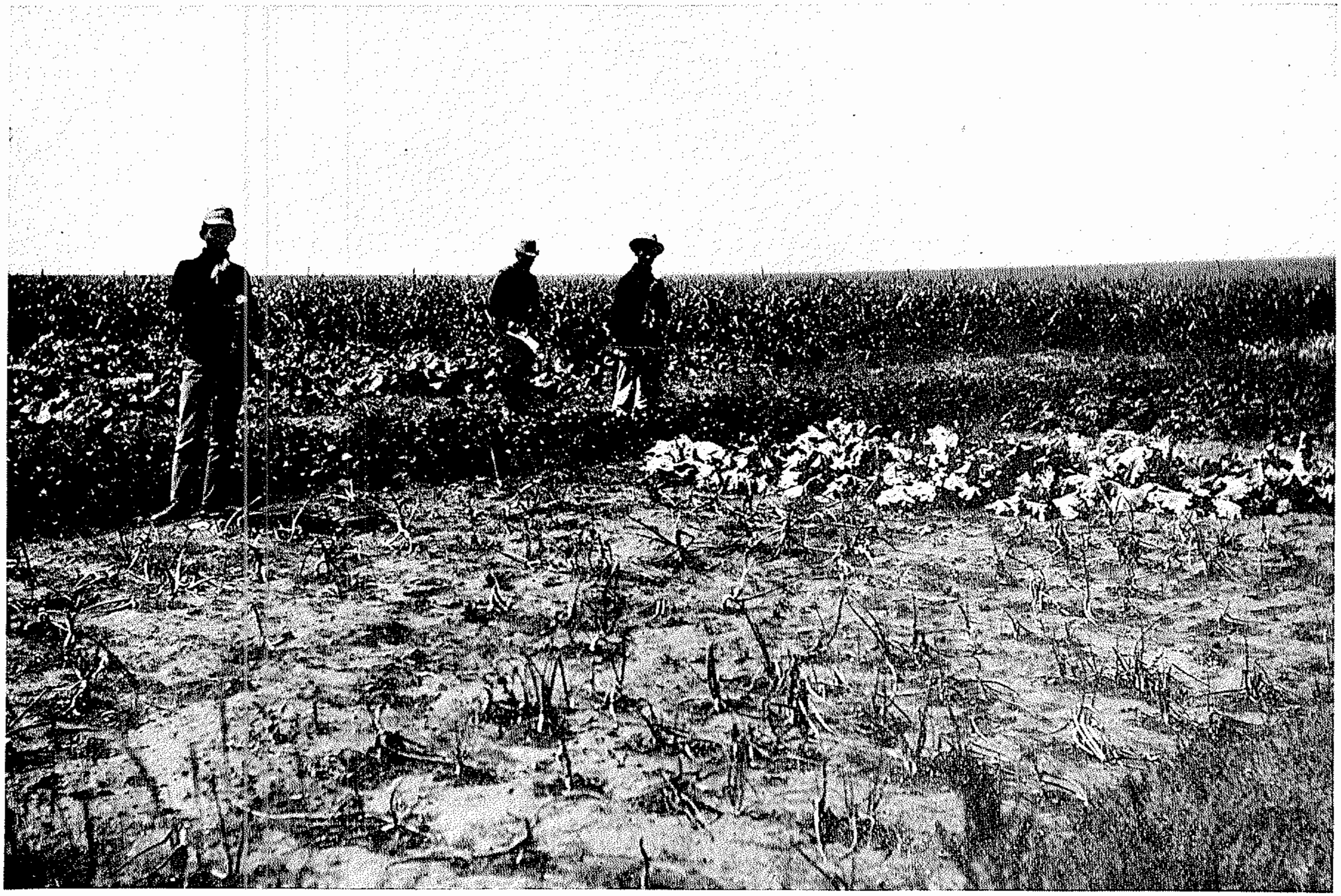
There seems to be no doubt that it abounds in ingredients well adapted as food stuffs for many plants, particularly for grasses. Grasses grown upon it seems especially nutritious and appetizing. The buffalo grass, *Bulbilis dactyloides* and Gramma grasses, *Bouteloua oligostachya* and *hirsuta* flourish upon it in drier places during the rainy season, as does also in damper places the wheat grasses *Agropyrum repens* and other species. As long as there is moisture, these and other grasses grow rapidly, but as all the moisture is near the surface, and does not extend deeply, not more than a few inches, when the dry season comes on moisture is soon dissipated and the plants dry up quickly with all their juices, starch and sugar in them so nutritious that cattle may fatten upon them as rapidly as upon grain. And for a similar reason, the food is concentrated by drying and the juices of the digestive canal are rapidly absorbed by it.

The longer the moisture lasts, the longer and larger the vegetation grows. On the bottom lands along the Cheyenne and in flats of higher levels where moisture is retained longer; the wheat grasses were found in 1902 growing so tall, with prominent heads, ripened so much like wheat, that it was difficult at first to determine certainly that it was natural instead of cultivated product.

The Pierre clays furnish the gumbo soils, whether on the hills or on the flats where the materials have been rearranged. So there are gumbo and clay flats along streams and water courses

*Second Annual Report of Progress U. S. G. S., Hayden, 1870, page 91.

Plate 28.



Indian garden on Fox Ridge northeast of Leslie, July 24, 1902. 14 kinds of vegetables doing well.

where clay is an eroded rock in the vicinity. Gumbo or clay soils, nearly universal in the Pierre area, are lacking in Fox Hills, but are found again locally in the Laramie.

Another feature of the Pierre is the occasional absence of soil, sometimes from the rapidity of surface erosion and because of too short duration of moisture; these combine in the steep slopes along streams. Another reason is the occurrence of mineral salts in sufficiently concentrated form to kill vegetation. This happens in shallow basins on flats where the drainage over considerable surface is concentrated. This occurs on stream bottoms, and sometimes in basins caused by land slides. Similar conditions occur even on glacial drift where the till is largely composed of rearranged Pierre clay. Such areas show the strength of mineral salts by the amount of whitish efflorescence which appears in time of drought.

One way of getting rid of the excess is to shovel it away to some place where it will do no harm. It may be helpful as a fertilizer for some sandy area. Often the amount is so small that ordinary tillage so scatteres it that it is harmless.

The soils of the Pierre formations are often almost pure clay. Yet over much of the flatter portions of the soil has received more or less sandy dust from the wind and by wash from the Fox Hills formation higher up the slope, or from the capping of stream terraces so that has considerably porosity. We may sum up the advantages and disadvantages of the Pierre soils as follows:

A. Advantages: 1. Lasting fertility. 2. Retention of the slight rain-fall near the surface. 3. Entire absence of coarse material which would interefere with cultivation.

B. Disadvantages: 1. No under-drainage. 2. Incapacity to resist drought. 3. General tendency to cake and clod. 4. Too great abundance of mineral salts. 5. Eroded rapidly on slopes.

Fox Hills Soils.—The Fox Hills furinshes sandy soils, though this is less marked when the lower clay portion is the subsoil. The table lands between the Cheyenne, Moreau and Grand Rivers have a sandy easily tilled soil. These correspond to the area marked as Fox Hills on the geological map. It withstands drought well for much water is stored in the subsoil, and is given back to the surface in time of drought. Dr. Hayden, the pioneer geologist of the region, says, "Very soon after passing the Big Cheyenne River, the traveler will readily recognize its presence (Fox Hills) by the mere cheerful appearance it gives to the surface as well as by the greatly increased growth of vegetation."

The native grasses are thicker and taller, and barren places disappear. Shallow loamy or sandy deposits of this formation with a clay subsoil have the advantage that the clay prevents the slight rain-fall from running away underground, and the sand mulches the surface so to prevent its escape too rapidly into the atmosphere. Such conditions obtain not infrequently in the region mentioned. Native vegetation resembles quite strikingly that of western Iowa. During the summer of 1902 the rain-fall was greater than the average; and we were pleasantly surprised to find the last of July high up on the southern edge of the so-called Fox Ridge, an Indian garden in which 14 different kinds of vegetables were growing finely: potatoes, corn, melons, onions, beans, cabbages, etc. A view of this is given in Plate 28. The general appearance of streams in the Fox Hills uplands is given in a view of Bear Creek, in Plate 29; and of stream just cutting through the Fox Hills to the Pierre clays underneath, in Plate 14.

Laramie Soils.—It will be remembered that the Laramie is a heterogeneous formation including the clays like the Pierre, also loams and sands, some of them consolidated into stone, but the loamy and sandy characters prevail almost everywhere. Circumstances tend to mingle the clays and sands on the slopes in advantageous way. Of course, the mixture will be sometimes more clay and sometimes more sand, and therefore a greater variety of conditions are found than upon the Pierre. The interstratification of the clays and sands tend in the same direction. Sometimes there may be narrow areas of bare "bad-lands," Fig. —, resembling those of the Tertiary but these are comparatively rare, except upon abrupt slopes near the streams. In general, the soil of the Laramie and its vegetation resemble those of the Fox Hills. The clay soils which are found on slopes below exposure of clay or on flats by streams resembling closely those already discussed under the Pierre, and what has been said of the Fox

Plate 29.

A. Bear creek, looking west, a typical upland valley on the Fox Hills.

Plate 30.

B. Soda Lake, looking west. One of the largest upland basins.

Hills will frequently apply to the sandy and loamy tracts. The Laramie region therefore, is not much different from that of Fox Hills, except that it is more varied. There are more steep slopes, more barren spots, more alkali and rapid erosion. Sometimes areas of a few acres may be too stony for cultivation.

River Terrace Soils.—These form an important portion of the area. They all have the common characters of alluvial terraces in that the materials are transported and their qualities correspond to those of the strata from which their ingredients have come. Those, of course in this region derive most of their material from the formations already reviewed ,with some additions from a distance which may, however, be neglected.

They are all more or less clayey, though those of the Cheyenne, and possibly little less so those of the Missouri, are loamy and sandy. The lower terraces have less coarse material than the higher. The subsoil resembles that of the upper Fox Hills. The sand and gravel in places produce too much under-drainage, and this, with the narrowness of the areas, are prejudicial to the retention of moisture. On the Missouri the thick loamy capping tends to modify that tendency, and in the case of the high terrace of the Cheyenne, the bradth tends to retard drainage.

Glacial Soils.—These are found predominant east of the souri, but are not found west of that stream. There is usually about the same soil on moraines as on the smoother till within or just outside. In the former place the soil is only a little more stony and gravelly, with much variation in short distances. It may in some cases be too gravelly or sandy to keep the moisture near the surface, but in general, there will be littl difficulty from this source. These glacial soils are like those of Iowa and Minnetsota in that they are composed of an intimate mixture of the materials ground from the rocks over which the glacier has moved. They are loamy with a more or less porous subsoil to a few feet down, when the deposit becomes impervious to water, hence in this respect it resembles the Pierre clays. Moreover, the till is composed largely of ground up Pierre shale, and has the same prevalence of soluble mineral salts, carbonaceous matter and iron, so that the subsoils in the two cases much resemble one another.

The impervious lower till prevents the sinking of the rain-fall below the surface, and the peculiar basin surface of the till prevents its running off, so that over much of the till little of the rain-fall is lost except by evaporation. It accumulates in basins sometimes so that it appears above the surface, but often its presence is shown only by the more abundant growth of grass and other vegetation. Of course, if the surface is cut by drainage channels, or the surface is cut by ravines, more of the moisture is carried away.

Water Supply.

From what has already been said, it appears that the soil is rich, and much of the region lies beautifully for agricultural purposes, and the main lack is water. Here the fundamental difficulty is the deficiency in rain fall. Though our data are few, they are sufficient to show the main facts.

Rain Fall.—To present this matter we have the data from seven stations at which observations have been made. Three of them for more than six years. Besides these we will take the record at Ashcroft on Little Missouri, little west of our area. The data are given in the form of the following table:

TABLE OF AVERAGE RAINFALL.

LOCALITIES	Years	January	Feb'uary	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Annual	April to August	May to July
Ashcroft	12	.50	.42	1.56	1.24	2.35	3.01	2.25	1.17	.93	.55	.53	.36	13.87	10.02	7.61
Cherry Creek..	9	.09	.07	.85	1.26	1.44	3.14	1.55	2.24	1.14	.46	.36	.31	12.86	9.60	6.10
Little Eagle...	3	06	.27	1 26	1.19	1.50	2.51	1 05	4.19	2.49	.77	.31	.24	15.36	10.44	5.06
Mound City...	1	T	.27	.62	.12	.58	5.12	3 69	1 83	1.65	1.64	.05	.35	15.92	11.34	9.39
Pedro.........	1	T	.10	.43	.87	2.21	2.30	5.65	2.65	1.81	.68	.18	.29	17.17	13.68	10.56
Pierre.........	12	.51	.38	.86	1.95	2.31	3.41	2.18	1.65	97	.65	.46	.44	15.77	11.50	7.90
Fort Sully.....	22	.44	.43	1.06	1.89	2.60	3.25	2.81	2.05	.95	.57	.44	.47	16.96	12.60	8.66

From the above it appears that for most of the region, namely from about 50 miles west from the river westward, particularly away from the larger valleys the average annual rain-fall is less than 15 inches. The rain-fall increases toward the east and probably near the streams. Along the Missouri there is about 17 inches, but nowhere in the area would the annual average rain-fall be greater than 18 inches.

For comparison we insert the average rain-fall of other localities. South Dakota as a whole, 20.88; the southeastern part about 26 inches and the northwestern part 15 inches. Nebraska as a whole, 23.33; western Nebraska, 13-18 inches. Plains of Germany and Russia, 20 inches. Christiana and a large part of Scandinavia, 21 inches. The north coast of the Gulf of Bothnia, 16 inches. Some parts of Sweden, 14 inches.

The larger portion of the rain-fall in our area comes in the growing months, April to August inclusive. From the table it will be seen that in every case more than two-thirds of the rain-fall for the year is in these months, and that generally more than one-half falls in May and July inclusive. In no case does the rain-fall in growing months fall below 9 inches, the amount which Major Powell, director of the U. S. G. S., said would be sufficient for raising a crop, if it came right. It certainly comes right as far as the time is concerned. Nevertheless, there are two or three quite serious obstacles. (1) Uncertainty of the amount of rain. The figures given above are averages, and some years they fall quite low. At the stations in our area they have not fallen within the 4 years below 10 inches at any point, and their highest maximum is 19.53. This shows less fluctuation than often appears elsewhere. (2) The intense evaporation. Here we have a very imperfect record. The evaporation from the ordinary surface may be difficult to obtain, but that from open water may be determined with considerable accuracy. At Fort Douglas, Utah, where the rain-fall and other conditions are not so very different from the area considered, the evaporation for 1890 was found to be 42.16 inches, according to U. S. G. S. According to the Signal Service the evaporation at Salt Lake City, not far away, was 74.4 inches. At Fort Blass, Texas, the evaporation, according to U. S. G. S., was 95 inches, and according to the Signal Service, 82 inches at El Paso.*

More recently data have been collected from the plains of which our area is a portion, as follows.**

Locality.	Rain Fall.	Evaporation.
Amarilo, Texas.	21.55 Inches.	55.4 Inches.
Dodge, Kansas.	20.4 Inches.	54.6 Inches.
North Platte, Nebraska.	17.66 Inches.	41.3 Inches.
Bismarck, North Dakota.	18.5 Inches.	31.0 Inches.
St. Vincent, North Dakota.	19.5 Inches.	22.1 Inches.

From these we see that there is a decrease of evaporation toward the north. Our area may be considered as having a little greater evaporation than Bismarck, while the rain-fall is considerably less.

Professor Swezey of the Agricultural Experiment Station of Nebraska, estimates that the evaporation from open water in western Nebraska, corresponding in rain-fall to our area, is about six feet a year (Nebraska Geological Survey, vol. 1, p. 44). The evaporation is greatest in July and August, when it sometimes reaches, at Fort Douglas, 10 inches; at Fort Bliss, 13 inches, per month.

(3) The frequent occurrence of hot southwestern winds, when the relative humidity has been known to fall as low as 20 or even 14 per cent. These are usually with high temperature.

At Cherry Creek the maximum temperatures of 112° and 114° have been reported for July, and it is not uncommon for 105° or 106° to be reached in July or August at any one of the stations named. These southwestern winds are veritable siroccos, withering or even killing crops within a few hours. No remedy has yet been found for this obstacle. It is hoped that the planting of trees on the sand hills of Nebraska, and the location of garden spots on the northern slopes may do something to modify their effects.

It is often argued and sometimes firmly believed that the climate of the State is undergoing progressive change, that the waters from the artesian wells, and the cultivation of the sur-

*Fourteenth Annual Report U. S. G. S., volume 2, page 154.
**Twenty-first Annual U. S. G. S., P. 1, page 677.

face so that more moisture is retained in the earth, have perceptibly increased the rain-fall. It is claimed that this is shown by the successful cultivation of crops where several years ago there was only failure. With reference to this belief we quote from Prof. F. H. Newell, the head of the Hydrographic Division of the U. S. G. S.*

"There is a popular belief that by spreading the water on the surface of the ground through irrigation, the rain-fall is increased by the addition of this water to the air through evaporation. There is no question that evaporation from the soil, especially from large tracts of cultivated land, must tend to lower the temperature near the surface and make the air far more humid, so that, as far as the feelings or sensations of men go, irrigation and consequently evaporation may tend to modify the temperature and make it better adapted for the comfort of man in the immediate vicinity of his operations. But, as for modifying the climate as a whole or bringing about such changes as will cause an increased rain-fall, it is doubtful if these operations can have the slightest influence, especially if the relative bulk of water contained in the air is compared with that which is added to the ground and escapes by evaporation to increase the amount and percentage of that already there.

"In this connection it is interesting to note that inland lakes with their vast bodies of water continually adding moisture to the air increase the rain-fall only to a slight extent, if any, around their borders. If these vast stretches of water do not have a decided and perceptible influence on the rain-fall of the country, it seems hardly possible that the smaller scattered areas of earth moistened by irrigation in extent hardly one per cent of the entire area of one county can have any measurable influence upon the distribution of rain. The benefits to be derived are, however, not dependent upon increasing the humidity of the atmosphere as a whole, but only that minute fraction of it which happens to be in immediate contact with the parts of the earth's surface utilized by man."

Prof. G. D. Sweezey, director of the Weather Bureau of

*Twelfth Annual Report U. S. G. S., Part II, page 234.

Nebraska, published in 1896, the results of weather observations in that State for 47 years.*

In this he concludes that there is no evidence of increase of rain-fall from that State. "If we divide the entire series of 47 years into two periods of 24 and 23 years respectively, the average rain-fall of the first period will exceed that of the last by only about an inch." If the year 1849 (which was unusually wet) were omitted from the series, "the mean precipitation for the 23 years from 1850 to 1872, is 23.55 inches, while that for the 23 years since is 23.46 inches." From this the conclusion is obvious that cultivation of the soil has not increased the rain-fall in Nebraska. A similar conclusion was reached several years ago from the data obtained in Kansas, according to the judgment of some. Dr. F. H. Snow, however, who has made the subject a life study, claims a distinct and steady increase, amounting in 40 years to from 3 to 4 inches.

Some are asking whether the multiplication of artesian wells, as has been done east of the Missouri River, and which may doubtless be done over large portions of this area, may not increase the rain-fall. An enthusiastic citizen of our State (real estate man) has recently ascribed the more favorable character of the last few years in this State to the influence of artesian wells. He estimates that 115 billion gallons of water has been furnished the State the last year from artesian wells (50 billion gallons would be nearer the truth), and assumes that this must have had great effect upon the climate. The fallacy of this may be readily shown by a little calculation. One hundred and fifteen billion gallons would cover a square mile 557 feet deep. The same amount spread uniformly over an area of 15,000 square miles, which is a very moderate estimate of the artesian area east of the Missouri River, would amount to .44 of an inch, whica would be equivalent to one fair shower. Think how slight compared with the floods which filled the lake beds of the same area in 1881, and yet in a few years drought ruled the whole region with rigorous hand.

Surface Waters.—Under this head we include lakes, springs and streams.

Lakes and Ponds.—The only regions affording conditions

*Bulletin of Agricultural Experiment Station of Nebraska, volume 8, article 4, Rain Fall of Nebraska, p. 138.

for lakes are the table lands of the Fox Hills and Laramie formations and the uneven surface of the glacial till. Of the former the largest is in the northwest quarter of T. 17 N., R 25 E., is two or three miles in length. Plate 30. It is quite shallow, and its waters slightly charged with carbonate of soda, enough to effervesce with acid. It probably originated with wind action, but has been occupied by water much of the time as is shown by its stony shores. It seems to be just above the lower clay stratum of the Laramie. Another lake is 10 or 12 miles southwest which was not visited.

A number of open shallow ponds are scattered over the table lands north and south of the Moreau. They had water in them in 1902, probably many years they have none in sight. All which we saw were filled with grass and water plants. There are no traces of alkali basins as are frequently found upon the Pierre and glacial till.

East of the Missouri the largest lake bed in our area is the Blue Blanket Lake or marsh in northern Walworth County. It, with several smaller ones, and a long one near Mound City, are the results of glacial action and of the partial filling of a shallow valley outside of the second or Gary moraine, which lies a little east of it. In dry seasons the water rapidly disappears.

Shallow basins of irregular form may be found over the whole area marked as "Glacial Drift" on the Geological map, but in ordinary seasons they rarely contain water, except in springs and after severe rains.

Springs.—These appear quite frequently near the head of ravines which cut the junction of the Fox Hills and Pierre. The water is accumulated in the sandy deposits under the former, and under favorable circumstances will be brought to the surface if not in running streams, at least in water holes. These are connected with ground water moving slightly down the valley, and it may enable one to find good water if he remembers that from this circulation of the water the upper end of each pool has recently filtered through from the one above, and is therefore purer and sweeter. In the drift areas east of the Missouri similar conditions prevail between the looser weathered portion of the drift and the impervious unweathered below. Here also the streams are broken into water holes connected by ground water.

Another class of springs are supplied from the gravel deposits capping terraces. The gravel retains the rain-fall, and even conveys it from a distance in buried channels. When they are cut by bluffs, the water escapes copiously. Perhaps the most notable case of this sort in our area is near Fielder, where an old channel of the Okoboji ends abruptly upon the edge of the terrace. In the Laramie it will be remembered there are various beds of sands and loam separated more or less completely by impervious layers of clay. These masses of sand freely receive the rain-fall and store it up, conveying it oftentimes some distance. Where ravines have cut down to an impervious stratum the water in the sandy stratum above appears as a spring. A notable case of this sort is found at Coal Springs near the Deadwood and Bismarck trail. There has been no careful effort made to note and locate springs upon the map.

Streams.—These have been already discussed in a former section, and we will speak of them further in connection with the location of shallow wells in a subsequent section.

SUBTERRANEAN OR PHREATIC WATERS.

These include shallow wells, deep pump wells and artesian wells.

Shallow Wells.—When the rain falls upon the surface a portion of it is absorbed and sinks into the earth until it reaches an impermeable stratum, it then accumulates until it obtains a quantity sufficient to run or seep through the ground towards some lower point. If the impermeable stratum comes to the surface water will appear as a spring at this lower point. Since the weathered part of the rock or soil is near the surface and where it is unweathered it is usually impermeable the water usually tends to flow below the surface parallel with the movement of the water upon the surface after a shower, or in a stream. Hence, shallow wells are most apt to find the water in the bottom of the valley, and the longer the valley and the steeper the slope and more abundant the rain-fall of the region the more certain it is that water will be found, and the more abundant at that point. Where rain-fall is abundant, shallow wells may be obtained at almost any point of the surface, and especially so in fine porous material. Where the rain-fall is deficient or where the ground is so coarsely porous so as to allow the water to run away rapidly, it may be difficult to obtain any quantity of water upon the side hills. In the area under consideration, shallow wells may be obtained on the glacial drift or in the Pierre if the area draining past the well is of considerable extent. In the case of the Fox Hills and Laramie, and also upon the wide terraces, shallow wells from 10 to 50 feet in depth may probably obtain a moderate supply of water. Unless the valley or basin draining to the well is unusually large, the supply will not be copious. Of course, near the streams, where the well reaches below the surface of the water there will be an unfailing and copious supply, provided sand or some equally porous stratum is penetrated.

Deep Pump Wells.—Underneath the glacial till or boulder clay there is frequently a stratum of sand or gravel separating it from the underlying Cretaceous clays. Where this occurs it usually contains water, unless it is too near the edge of the upland, or if it is at an unusual height, so that the water has drained away from it to lower levels. This stratum may be struck at a depth of 100 to 200 feet in the areas marked "Boulder Clay" upon the Geological map.

In the Laramie formation it will be remembered that extensive deposits of sand and loam are found. These absorb water readily, and convey it miles away, so that it may be far below the surface and be reached only after drilling 100 feet or more. We are not aware that wells of this sort have been attempted in the sparsely settled region covered by the Laramie, but in case easier sources of water fail any where, we would call attention to this as a probable source of excellent and possibly copious waters over a considerable area.

In the Pierre formation, however, the case is by no means so hopeful. Not only are the waters apt to be contaminated by mineral salts as has already been remarked, but waters are much less copious. It is doubtful whether any wells will find water in quantity in the Pierre, except in shallow wells in the bottom of considerable valleys.

Nevertheless, it will be remembered that there are horizons or levels of concretions of considerable size. These attest the presence of circulating waters, and it is possible that these layers are sufficiently leached and porus in some places to afford valuable wells.

Still deeper than the Pierre are two or three horizons in the Colorado group, viz., in the Niobrara chalkstone and in limestone layers corresponding to the Greenhorn limestone, and also from sandstone strata which resemble in character sometimes the thicker sandy layers of the Dakota below, which may furnish valuable waters. These, after being struck which may be at a depth of 400 or 500 feet, may rise considerably nearer the surface, though not so as to produce flows in this area. Some of these strata afford soft water elsewhere.

Artesian Wells.—As has already been remarked, this whole area is underlaid by the Dakota sandstone which affords artesian wells in large numbers in the James River valley. Copious artesian wells have been obtained from it at Pierre, Pearl Township, Sully County, Cheyenne River Agency, and Campbell; also at some other points in our area, all of which are marked upon the map. The waters not only carry with them gas in nearly all cases, but they are of quite high temperature, and are abundantly charged with soda salts so as to be soft. The salts are in no case, however, so abundant as to render them unwholesome for drinking and other domestic uses. In the valley of the Missouri the pressure which they exert is so great that they may be used advantageously for power. At Pierre a pressure was obtained of 210 pounds; at Cheyenne River Agency of 205 pounds; at Campbell about 100 pounds. From these it is estimated that the head is sufficient to produce wells along the Missouri which will flow at the height of nearly 2,000 feet A. T. From the increase of head elsewhere it is estimated that the head increases in height toward the west at the rate of about 4 feet per mile, which would rise nearly as fast as the general surface of the country in that direction. Along the western line of our area the pressure would probably be sufficient to produce flows at the height of nearly 2,800 feet, conservative estimates of the height of head are marked on the profiles. From these we may estimate that probably one-half of our area might obtain artesians wells. Those, however, near the limit of pressure would flow very feebly and probably be of short life. It is probable that they may be obtained upon the broad high terraces of the Cheyenne River, and would prove valuable in supplying stock and affording garden irrigation. Estimates as to the depth at which the Dakota would be struck may be made from the profiles and sections, which are published herewith.

Reclamation of the Region.

The whole of our area would be classed as subhumid, i. e., with sufficient moisture to insure crops without irrigation and not yet dry enough to rely exclusively on irrigation as in truly arid regions.

It is well adapted to grazing purposes in its present condition, but if the crowding of population westward continues as it promises at present, agriculture may be attempted and therefore several recommendations are here made, which may be found helpful in developing the region for its highest usefulness.

(1) All efforts should be made to retain rain-fall in the region. This may be done by damming draws and ravines where practicable. Such work may accomplish a two-fold benefit. In the first place it may increase the humidity of the air in the vicinity, sustaining groves or other vegetation by evaporation or seepage; and secondly, in furnishing water for irrigation where it may be practicable to do so. In this way much moisture may be held on the upland divides.

In several favorable localities dams may be thrown across the larger valleys, and by general action floods may be in this way retained which could not be accomplished by individual efforts. The rapid fall of medium-sized streams and considerable flood plains along the Cheyenne, Grand and Moreau Rivers are favorable to small irrigation plants. Before extensive works are undertaken careful investigation should be made of the size of the supplying catchment basin and the practicability of obtaining material for dams, which is deficient at many localities.

Upon the Pierre comparatively little loss from seepage need be counted upon, but in the Laramie and Fox Hills care should be taken to locate reservoirs so that sand and loam strata will be avoided, otherwise loss from seepage will be very considerable. In case it is difficult to avoid them in a given locality, pains should be taken to line the reservoir with "gumbo" or clay. With care reservoirs may be made in this way even upon sand hills. Clay beds are usually not far away from any point in this region.

Doubtless the bottom lands of the larger streams would be irrigated by damming streams and adjacent ravines, but certain obstacles may make it uneconomical in some cases. One is the difficulty of carrying ditches around the sharp bends of the rivers where they crowd against high banks which are liable to cave. Another is the possible inadequacy or variability of the water supply. The former may be easily estimated by survey in each case, but the latter can only be learned by a prolonged stream gauging and records of rain-fall.

(2) The prevention of prairie fires. This precaution which has been fairly observed in late years, tends to increase the amount of water absorbed by the soil, to reduce the evaporation, and to increase the growth of grass. The formation of sod facilitates the shedding of rain so as to increase the run-off as compared with a tilled surface. But this is particularly true of sloping surfaces such as hillsides, and of the stemless grasses like blue grass. Where the surface is level or gently sloping or the vegetation is tall and comparatively rigid, it doubtless acts in the opposite way and does much to prevent water running off, and so increases the amount absorbed by the soil. Moreover, if the rain-fall is by light showers followed with sunshine, the vegetation may retain the moisture like a blanket and give it back to the air, but if the rain-fall is copious this will be an unimportant consideration.

When once the ground is moistened, the dry grass acts as a mulch, and even growing vegetation acts in the same way, except so far as the water is used in their growth and evaporated from their leaves.

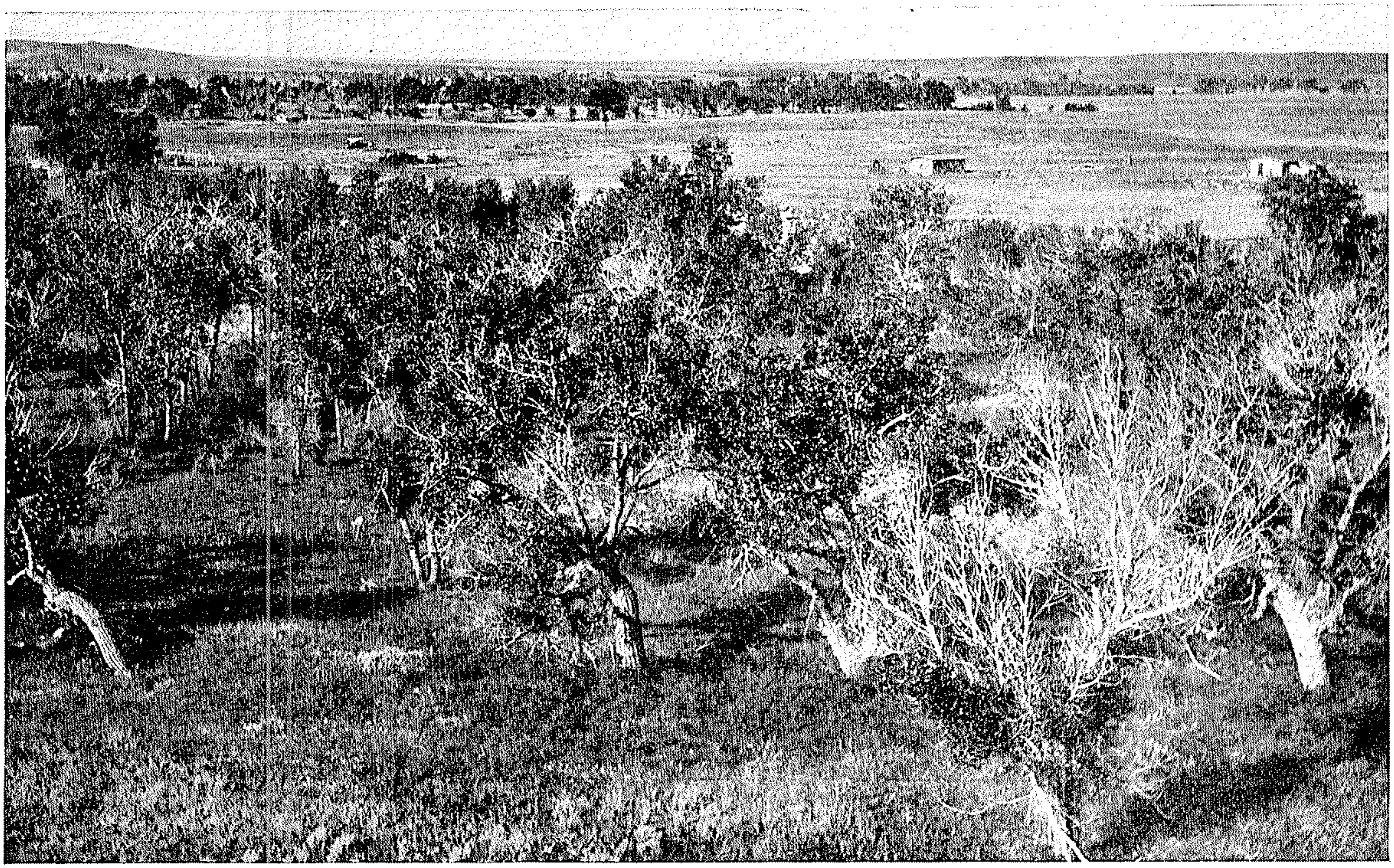
If prairies are burned, larger grasses are apt to be killed, particularly if this is done in a dry time, because the heat produced by the burning of the rank growth is sufficient to kill the roots. This is why prairies were formerly covered by buffalo, or other short grasses where the blue stem now abounds, since the checking of prairie fires. The former Indian method of burning the prairie is in its measure as truly the cause of the dry desert prairies, as the destruction of forests by white men, against which so much is said by writers on forestry.

(3) The planting of groves and forests. There are localities where the establishing of trees is well nigh an impossibility. It is doubtful whether it can be done upon a gumbo subsoil, unless in a bottom of a basin or valley large enough to collect enough water from the rain-fall to keep the trees growing to maturity. The same is true of every clayey till. The writer has known groves which flourished for several years until they had attained a size of six inches in diameter, and then nearly the whole grove died because they had exhausted their supply of moisture. On the other hand, trees are sometimes found isolated on the dry prairie and have held their own for years against the vicissitudes of the desert around them, because they had fortunately rooted in a ravine or depression which brought them sufficient water to tide them over the crisis of the most severe droughts. Sometimes we have seen them retrenched by the death of a large branch or the dying back of twigs, but still they live on. This is illustrated also by groves in the more arid regions. See Plate 31.

As we have seen already, the sandy soils and moistures near the surface which prevails over much of the Fox Hills area seems especially adapted for forestation. Sand hills are often frequented by oaks and pines in the midst of dry prairies because of the moisture retained in the sand. So also much of the Laramie and high river terraces offer possible favorable locations for the establishment of groves. The ravines seaming the sides of table lands, mesas and buttes, are all favorable for trees, particularly on northern slopes. A little concerted and persistent action, I have no doubt, would cover with trees much of the area under consideration.

The native oak, ash, pine, hackberry and elm seem the more promising, but better species may possibly be introduced from other regions. The only limit to the growth of trees will be the amount of moisture which may be stored for their sup-

Plate 31.



Rabbit Creek at Ashe's ranch. Typical cottonwood groves of the drier semi-humid region.

port. Ultimately the amount of rain must determine the supply. An important benefit of this forestation would be a reduction of the effect of winds upon the surface, and possibly a prevention of ɩy general effects of hot winds.

(4) The multiplication of windmills. These may be the more practical means of raising water for irrigating the river bottoms, especially where individual effort only can be depended upon, or where prompt results are sought. Moreover, they may be used where dams will be impracticable, and again in some cases dams and windmills may be used at levels above the reach of water in streams. Many valuable hints on windmill selection, construction and management, and also of other methods of raising water, may be found by consulting "Experiments with Windmills," Water Supply paper, No. 20, and "Wells and Windmills in Nebraska," Water Supply paper, No. 29. Either of these may be obtained gratis from the director of the U. S. G. S., Washington, D. C.

Though long shallow valleys leading from the mountains, which are common in Nebraska and Kansas, are wanting in this area, yet a few wide shallow valleys leading from such higher hills, as the Slim Buttes, like Antelope and Rabbit Creeks, may doubtless furnish water within a few feet of the surface, though there may be little or none upon the surface. This may be elevated by windmills, and support small irrigation plants of considerable importance.

(5) The Sinking of Artesian Wells. We need not repeat here what has already been said upon this subject in a previous section, but would simply add that this supply is likely to be of service on the high terraces along the streams. They will not be needed in the valleys, and the opening of them there should be discouraged, because their water is likely to be largely wasted, and because unless kept under strict control, they are likely to exhaust quite rapidly the pressure necessary to make this supply available on the higher neighboring terraces.

It is likely that this supply may be largely used in the Teton River basin. Small wells should always be recommended rather than large, because of less primary expense, of greater durability and of less danger of waste. Too extravagant ideas of this resource should not be entertained, though it is of incalculable benefit for water supply. One good shower will furnish more water for irrigation than a well running the year 'round.

By the realization of these suggestions we may confidently expect that much of the region will support agriculturally a considerable population. At least as surely as is much of the territory between the James and Missouri Rivers. Yet, grazing and stock raising should always be considered as the natural occupation for the region.

J. E. TODD.

Vermillion, May, 1904.

Two New Araucarias From the Western Cretaceous

By G. R. Wieland.

Research Associate of the Carnagie Institution of Washington

Silicified logs commonly referred to the much used genus *Araucarioxylon* are common throughout the Mesozoic. Especially all along the slopes of the Rockies do we find these logs, isolated, or often in groups commonly and appropriately called "petrified forests." It is of course true that we do not know what the final examination of this vast store of petrified tree stems, often of gigantic size, will reveal as to the actual variety of forms present. But so long as we describe these fossil trees in a more general way it might be better to use the broader term coniferous woods; for it is only recently that the important work of Penhallow* on the "North American Gymnosperms" has put us in possession of sufficient knowledge of the comparative anatomy of gymnospermous woods to enable us to make reasonably accurate determinations of the genera and species of extinct forms on the basis of wood structure alone.

However, while it is well enough known that the Araucarian, or Norfolk Island pine element was a conspicuous or even dominant one in most of the petrified forests of the American Mesozoic; whence it is all the more unexpected when we come to examine the record so far determined, for evidence as to the foliage and fruits of these magnificent ancient forests, that we find a most surprising dearth of recorded fact,—a few species of isolated leaves, and scarcely a cone that we remember, is all the story.

It is therefore of the very first interest that we are enabled to here add two new and well characterized species of Araucariæ, the one a beautifully silicified cone, the other a fragmentary but nevertheless finely conserved mould of a branch with its leaves. Indeed, the perfection of both adds additional wonder why these once prominent types of the North American forests have so completely disappeared, only leaving their descendents,

A Manual of the North American Gymnospherius; by D. P. Penhallow, pp. 374, with 48 figures in text and 55 plates. Published by Ginn & Co., Boston, 1907.

as in the case of so many northern migrants, in the Southern Hemisphere. It is all the stranger, when one remembers the fact cited by Seward,* quoting Hansen, that *Araucaria imbricata* yet thrives when planted in the open at Molde on the Norwegian coast in latitude 62° 44′. We pass on to the description of the strobilus.

Araucaria Hespera, Sp. Nov.

The type of this new Araucaria consists in the nearly complete half of the seed zone of a medium sized cone, of which only a minor portion of the apex is missing. The cone has suffered but little from erosion, unless the absence of the missing half may be assigned to this cause. It is noticeably flattened, and is of a yellowish to jaspery color. The portion conserved is silicified in unrivalled perfection, save that the seeds, as may be seen in the accompanying figure, are a little light of color.

This fine specimen was found several years since in the Grand River valley near the mouth of Cottonwood Creek, South Dakota, about 150 miles north of the Black Hills, and is therefore of uncertain, but probably upper Cretaceous age. Later it was sent to Dr. F. H. Knowlton, but was finally turned over to the present writer for study, in view of his interest in silicified plants, various thin sections have been cut, confirming the interpretation made from the larger features, but no photographs have as yet been made of these sections.

As appears so well in the accompanying photographic drawing, Fig. 1, no trace of the woody axis of the cone remains, and the spirally arranged megasporophylls are to be seen in the normal succession at their insertion points. Each forms a lozenge-shaped or sub-rhombic scar with a central pitting marking the main supply bundle. Both the right and left spirals run at about the same angle to the axis, this angle being only some 30°, the spirals running high. The striking resemblance of these megasprophyll insertion faces to those of the leafy organs of the branch figured below will be at once noted.

The peripheral portions of the cone are not so clearly shown, although preservation extends well beyond the tips of the seeds.

The Araucariæ, Recent and Extinct; by A. C. Seward and Sibille O. Ford. Phil. Trans. of the Royal Soc. of London. Series B. Vol. 198, pp. 305-411, plates 23, 24 and many illustrations in text. Published by Dulun & Co., London, 1906.

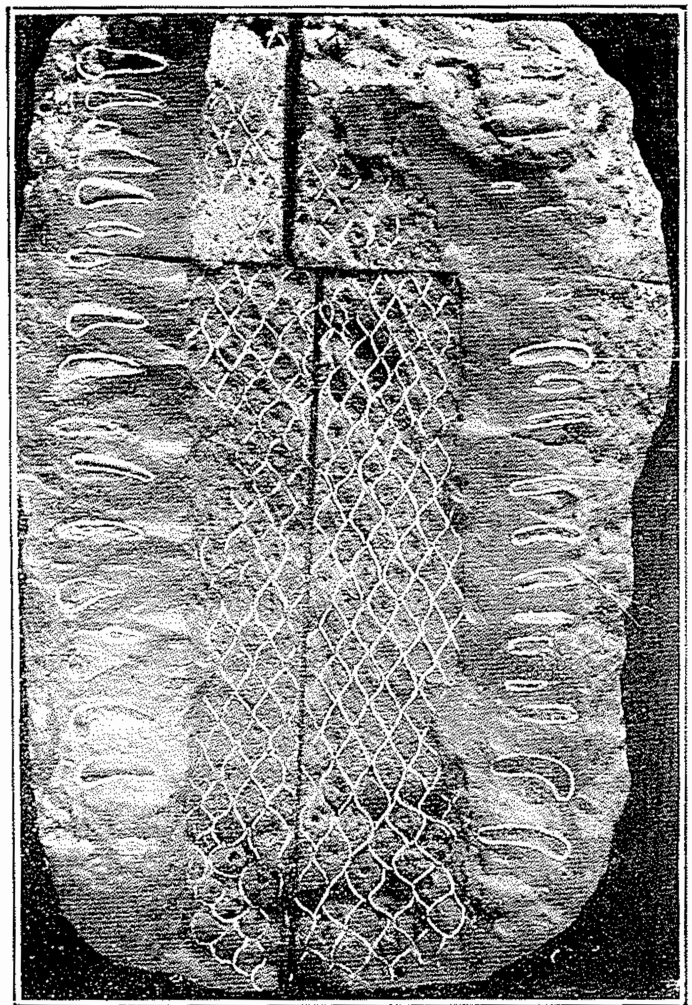


Figure 1. Araucaria Hespera

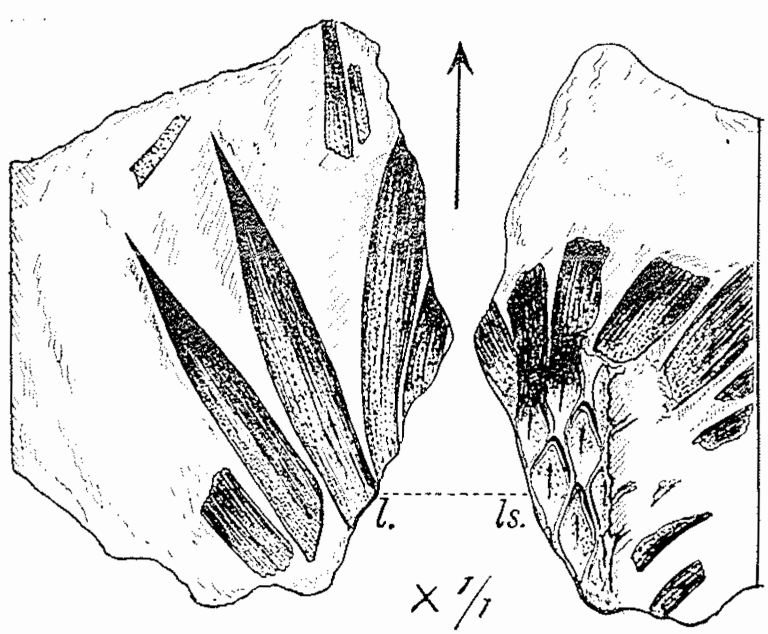


Figure 2. Araucaria Hatcheri

Despite the light to jaspery outer texture mentioned, except in the seeds an astonishing density of color is found on sectioning, it being exceedingly difficult to make the sections thin enough to bring out the splendidly conserved cell structure. As seen in thin sections the sporophyll tissues are rather small celled and appear young, as do the seeds outlined so clearly in the figure, and equally clear in the specimen itself.

The seeds are mostly a scant centimeter in length, being about the size of the smallest of the edible pine seeds or "piñons" one finds in the market, and having a somewhat hooked or curved clavate shape such as piñon seeds occasionally tend to show. While of too light a color to show their interior structure to entire satisfaction, the seeds when viewed in thin section inescapably suggest a proembryo stage, or else if not this, the presence of a prominent suspensor system. At any rate the embroyos were not yet formed at the time of fossilization and the type of preservation of the seed interiors lacks so little of being clear as to permit one to declare that if one had a dozen of these cones several of them would clearly show *pre*-embryonic structure. While it is not at all to be expected that such structures would differ greatly from the similar stages in *Araucaria,* it is of much interest that we have here for the first time a hint of their preservation in fossil conifers.

The cone before us is certainly of a wholly new specific, if not even generic type, and may appropriately be named from its Western origin, it being quite the first ever yielded by the great petrified forests of the West; though these were noted, as Professor Ward interestingly observed, even in the earliest years of the past century, and woven into the background of romance by Edgar Allen Poe.

It remains to emphasize the fact that *Araucaria hespera* derives a vastly greater interest from its preservation as a petrified specimen than can possibly attach to it as a new form. In short it adds another to the very few American stations yielding plants with structure conserved; and all such are of high importance and should be reported with the greatest care. Each adds its quota to a better knowledge of structural paleobotany, and to that completer history of plants based on the complementary study of fossil plant impressions and the far rarer calcified and silicified forms with conserved histologic structure.

Especially this new Dakota locality excites a lively hope that still other associated forms of the highest importance to a knowledge of plant evolution may yet be revealed by a careful determination of, and persistent search in the original locality. It will of course be more or less difficult to determine the exact locality, but if possible to be done it is well worth while. For should it yield other forms in the same exquisite conservation in which we find *Araucaria hespera* it must take rank as one of the most important of all American localities yielding fossil plants.

ARAUCARIA HATCHERI SP. NOV.

In view of the somewhat uncertain horizon of the silicified cone *Araucaria hespera,* and the comparative rarity of *Araucaria* foliage in the horizons in which the cone may have been imbedded, it is of practical interest to describe here the occurrence in the Laramie Cretaceous of Converse County, Wyoming of typical Araucarian leafy stems of a new species. These we have noted but once in the sandstone matrix cut from a Ceratopsian skull collected by J. B. Hatcher, and now in the Yale Museum.

I have carefully drawn this stem fragment as shown in the opposite figure 2, and have been told by Mr. Hugh Gibb, of the Yale Museum, who chiselled away the grater portion of the matrix of the skull twenty years ago, that the stem lay along the parieto-squamosal suture, and that it had a length of not less than two feet, all as well conserved as the fragment figured. Unfortunately this *Bruch stück* was all that was set aside for future reference, the rarity and interest of the specimen not having been recognized at once. The portion retained is, however, wholly characteristic. It was accompanied by various imperfectly conserved dicotyltdonous leaves.

So far as morphological characters go this fossil clearly belongs in the section of*Araucaria* represented by *Araucaria imbricata,* the well-known "monkey puzzle," rather than with any fossil known to us. But it has smaller and distinctly more lanceolate leaves which clearly indicate without further evidence that it is a new species. It may most appropriately be named in honor of its collector not so much because he collected it, as it proves unknowingly, as in the memory of a lamented friend, and in commemoration of his discovery, in these same beds of the handsome palmetto *Sabal rigida* Hatcher. Let us hope then that these discoveries are justly assigned some importance—that is to say that aside from their own immediate interest they may prove truly initial in pointing out, and in more fully and thoroughly emphasizing the importance of localities where our knowledge of ancient faunæ and floræ is yet destined to be vastly increased.

In order that it may be clearly understood just where the specimen described in the above article was found, the following note from Prof. Todd concerning the matter will be presented.

The interesting fruit described by Dr. Wieland, was picked up by Mr. Henry J. Ramsey, August 10, 1902, on the south side of Grand River a little west of its junction with Cottonwood Creek. When first submitted to Dr. F. H. Knowlton, he questioned whether it really came from the Laramie formation. When this was stated to Mr. Ramsey he made this statement "I picked it up twenty or thirty feet from the base of a cliff facing the river. It was on high ground and so far away from the river that it could not possibly have been washed down there by the river." It may be added that in strata not far away specimens of petrified wood are frequently found and also thin layers of impure lignite. All the strata in the basin of Grand River above this point belong to the Laramie formation as it is commonly designated.

THE STATE GEOLOGIST.

Preliminary Report on the Geology of the Rosebud Reservation, Including Gregory and Tripp Counties.

By Ellwood C. Perisho.

Historical Note.

The Sioux Indians, earlier called Nadowessioux (from which we get the simple word Sioux), and later called by some the Dakotahs; held, for perhaps two centuries, undisputed sway over that great stretch of territory from far east of the Mississippi to beyond the Black Hills on the west.

In 1837 these Indians ceded to the United States all their lands lying east of the Mississippi River. Later they gave to the government the land between the Mississippi River and the Big Sioux River.

In 1857 these Indians granted to the whites the right to settle between the Big Sioux River and the Minnesota line.

In 1858 the Sioux Indians ceded to the United States, 16,000,000 acres of Dakota territory between the Big Sioux and the Missouri Rivers. By 1860 all the Indians were west of the Missouri River except the few remaining on small reservations still maintained to the east of the Missouri River.

In 1868 the Indians, by treaty, were guaranteed permanent possession of all the land between the Missouri River on the east, *The plates are from photographs taken by the author in the Rosebud country. Plates 1 to 5 inclusive will show something of the recent development of the Indians in modern civilization.*

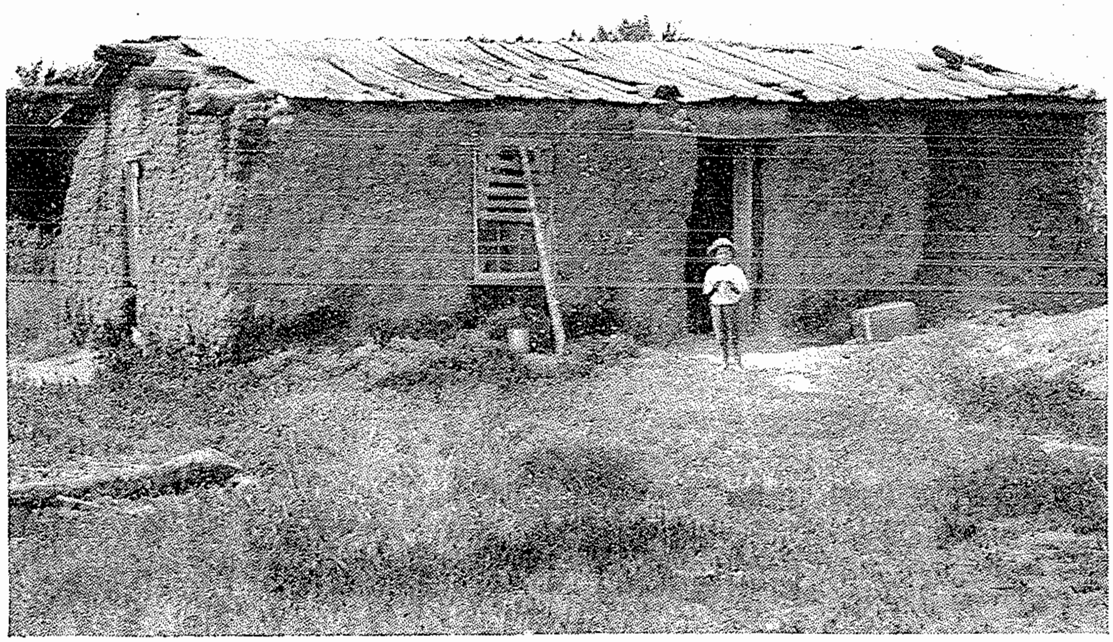
Plate 1

Indian Signal Hill. On the Ponca. Rosebud

Plate 2

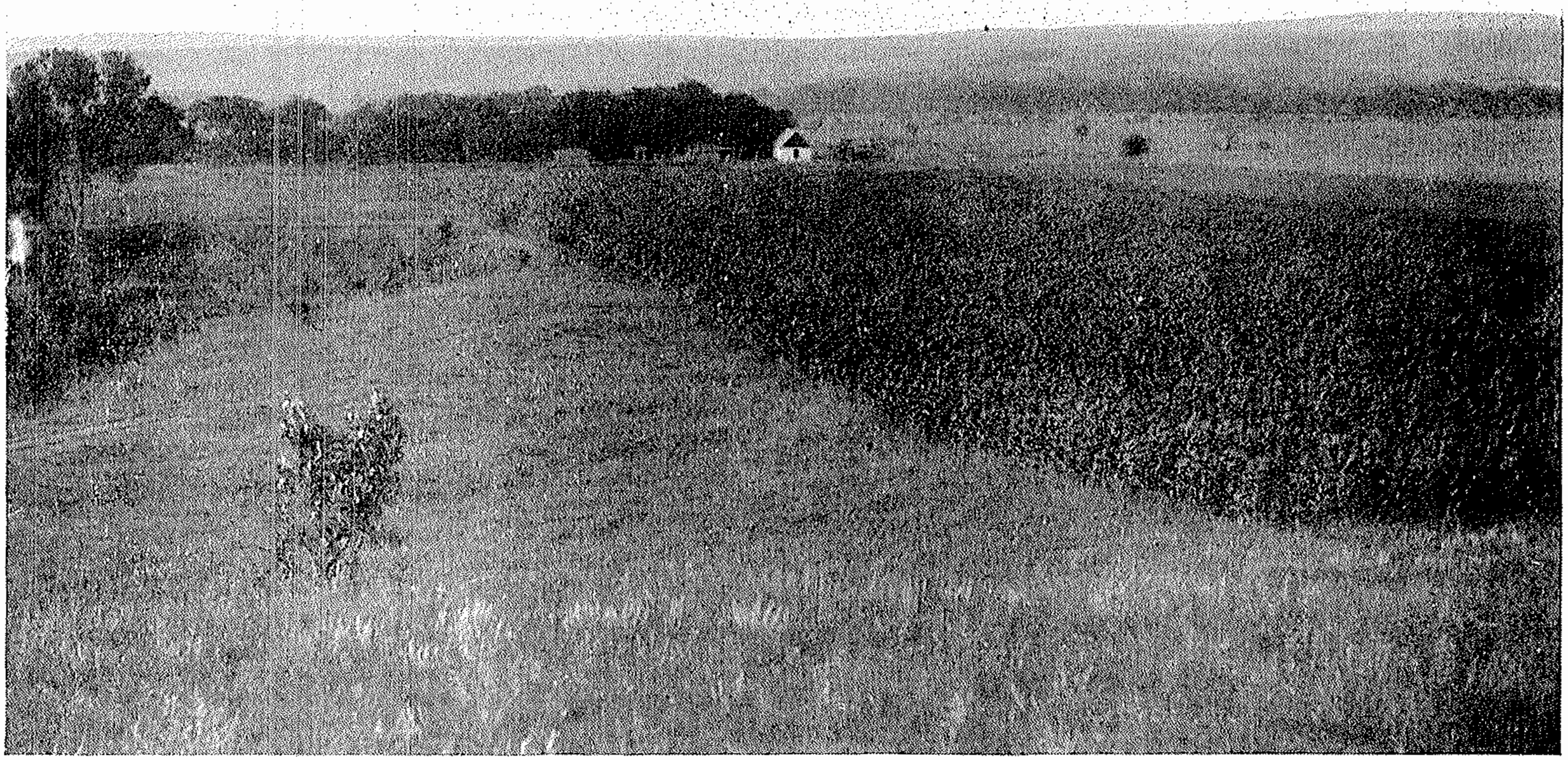
A. Indian Camp. Rosebud

Plate 2



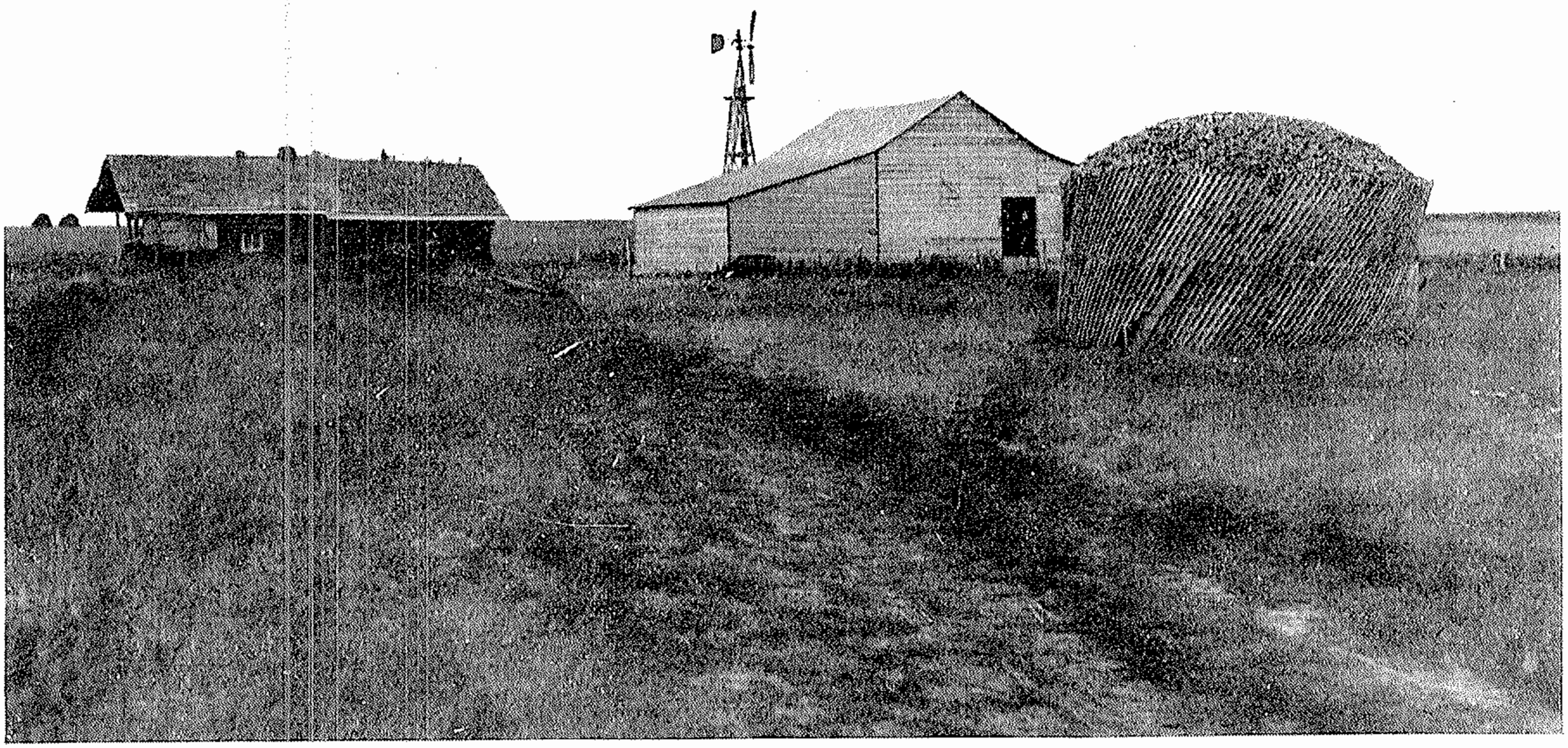
B. Indian Sod Home. Rosebud

Plate 3



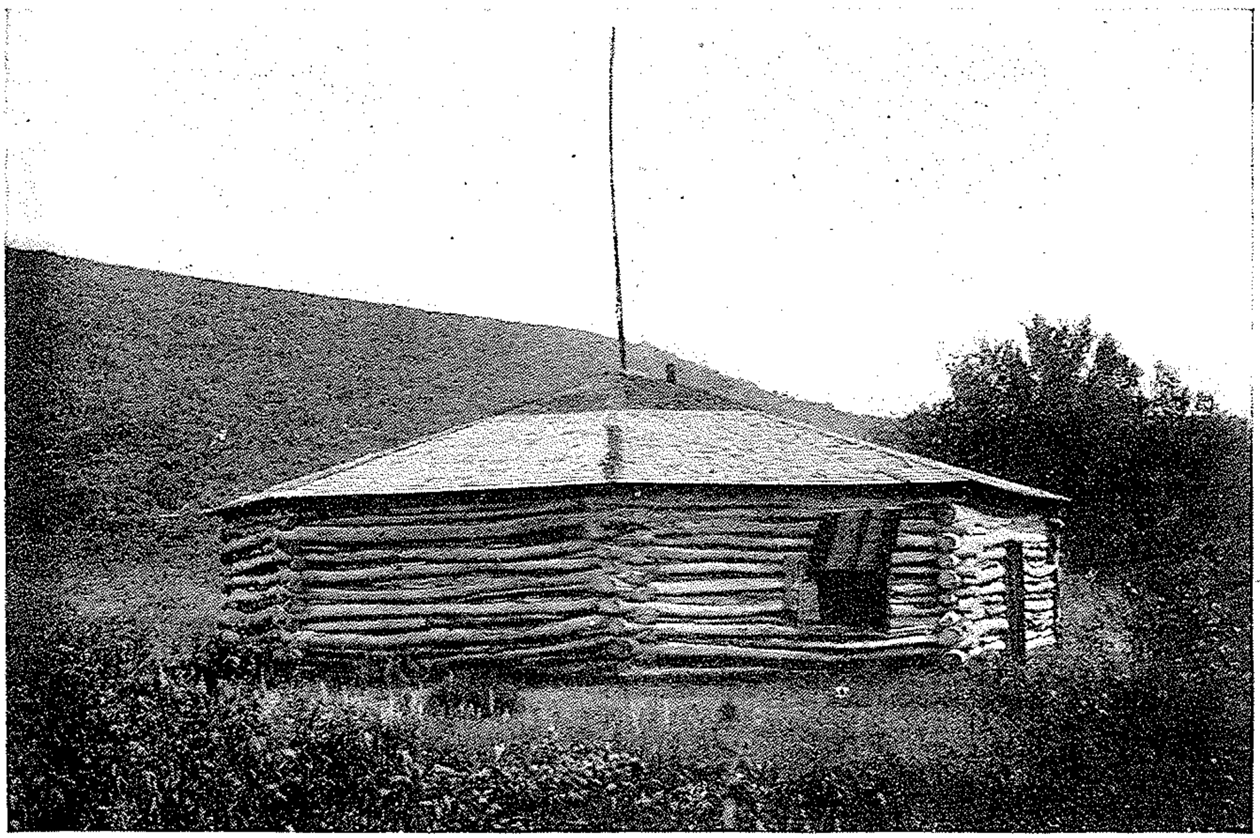
Indian Farm. Rosebud

Plate 4



Indian Home and Harvest. Rosebud

Plate 5



Indian Public Hall. On the Ponca. Rosebud

and the boundary of Dakota on the west; and from Nebraska on the south, to the 46° of latitude on the north; this north line comes now in southern North Dakota.

In 1875, 1876, 1877 and 1879 treaties were made and more or less ratified, restricting to smaller and smaller areas the Sioux Indians.

In 1882 the United States through a Commission, formed a treaty with the Sioux, which was signed by thirty-five chiefs, in which the Indians gave up over 10,000,000 acres of land lying between the Big Cheyenne on the north and the White River on the south. By the treaty of 1882, the larger number of the Sioux were confined within the strip of land between the White River on the north and the Nebraska line on the south; and extending from the Missouri River on the east, to the 103d Meridian on the west—a distance of about 200 miles from the eastern border. The width of this area is about 50 miles, thus making approximately 10,000 square miles. This remnant of the Sioux lands was later divided into two reservations, the Pine Ridge on the west and the Rosebud on the east.

In this report the Rosebud Reservation includes all that area north of the Nebraska line, south of the White River, east of the Pine Ridge Reservation, to the Missouri River on the east; except the southeast corner of the above area which had long been set apart as the Fort Randall Military Reservation. The south side of the Rosebud is the parallel of 43° north. The west line is near the 101° west longitude. The north and east sides are too irregular to be designated by a parallel or meridian. The most northern limit would reach 43°50′ north, and the farthest eastern extension is 98°30′ east, including the Fort Randall Reservation. The average length of the Rosebud Reservation was near 100 miles, the mean width was about 50 miles. This would give approximately 5,000 square miles as the original area.

Gregory County.

In 1888 the land east of near the 99° west longitude was ceded by the Sioux to the United States, and designated as Gregory County, named in honor of Colonel C. H. Gregory, formerly stationed at Fort Randall. In 1890 the above area was opened for settlement, and soon filled by homesteaders who found the lands well adapted to farming and grazing. In 1893 an Act of Congress opened the Fort Randall Military Reservation to settlement. In 1898 all land east of a line near 99°35′ west, was organized as Gregory County. In 1901 a treaty with the Sioux Indians relinquished all their rights to the land east of the above Gregory County line and west of Range 69.

In 1904 by proclamation of the President of the United States, the above area of Gregory County, consisting of over 4,000,000 acres, was opened for settlement. The Indians having first selected their own lands, which were officially allotted to them by the government. The better portion of the above lands were filed upon at once by the holders of the fortunate numbers after the drawing, the homsteaders giving $4.00 an acre for the same. Later settlers filed on many of the remaining quarters, for which $3.00 an acre was paid. Gregory has proved to be an excellent grazing and stock county.

Tripp County.

In 1908, after the necessary treaties were signed and allotments made, that portion of the Rosebud, known as Tripp County, which lies west of Gregory and east of Range 79 west, near 100¼° west longitude, was opened for homesteads. The registration occurred in October. Tripp County is approximately thirty five miles wide and a little over fifty miles long. It is claimed to have 8,000,000 acres upon which settlers may file in April, 1909. For the best of this land the government charges $6.00 an acre, payable in five years, and fourteen months of actual residence.

After taking from the Rosebud both Gregory and Tripp Counties, there is left of the original reservation, an area near 2,500 square miles in extent; being a little over fifty miles east and west and near fifty miles north and south. This report will in places refer to one or the other of the above counties separately, but in the main will deal with the reservation as it originally existed.

Data and Acknowledgement.

The information used as the basis of this report was obtained from a number of visits by the author to the area under discussion. The first and most extensive of these was in 1900, prior to his connection with the State University or being State Geologist. The second was in the summer of 1905. The State Survey sent a party into the Rosebud to make observations and collections in the eastern part, especially that portion which was soon to be opened for settlement. The party consisted of the State Geologist; Mr. Harold Barker of Ipswich, in charge of Topography and Leveling; Mr. Sheridan Jones of Vermillion, in charge of the Fauna and Flora; Mr. Claire Conrick of Chamberlain, and Mr. Albert Satrum of Irene, assistants.

The report of Mr. Jones, based on the field collection obtained during the summer work, will be found elsewhere in this Bulletin. Mr. Barker, assisted either by Mr. Satrum or Mr. Conrick, established a large number of levels at prominent points in Gregory County. Mr. Satrum also made many important geological observations. Mr. Conrick left the party before doing much geological work. Most of the tabulated data as reported by Messrs. Barker, Satrum and Conrick, along with the entire written report of the State Geologist, were destroyed in the West Hall fire at the University in 1906. Not only was the author's written report burned but with this were destroyed many of the field notes, maps and sections. Some first draft pages of the report and a few field notes happened not to be in West Hall and were saved.

The larger part of this report was written from data obtained in 1900, and subsequent visits. The author wishes to state that for some more recent facts, and some corrections and confirmations, he is indebted to N. H. Darton's able Professional Paper No. 32; also he wishes to acknowledge a valuable geological communication from Mr. Reagan, giving much important data near the Rosebud Agency.

ELEVATIONS.

The following elevations may be of value to those who are especially interested in this area of South Dakota. The heights of the Missouri River flood plain, and of places on it, are derived from the Missouri River Commission Reports. A few are from government surveys, but most are from levels established by the

State Survey or by aneroid barometer reading and eye level estimates made by the author.

	Feet.
Yankton, low water	1,157
Yankton Weather Bureau	1,233
Fort Randall, low water	1,236
Wheeler	1,250
Chamberlain, low water	1,323
Chamberlain Weather Bureau	1,363
Pierre, C. & N. W. R. R.	1,440
Bonesteel, Gregory County	2,000
Plain near Gregory, Gregory County	2,200
Plain near Dallas, Gregory County	2,225
Plain, near Winona, Tripp County	2,200
Plain at Artesian Well, Rosebud Reservation	2,600
Oak Creek School	2,400
Rosebud School	2,700
White River Valley, near water, north of east part of Tripp County, down to	1,400
White River Valley, near water, north of western part of Tripp County, up to	2,000
Hills, Bijou, east of Missouri River, S. Brule Co.	2,000
Hills, east of Missouri River, northern part of Charles Mix County	2,000
Hills, near Iona, Gergory County, west of the Missouri R.	2,000
Hills, between Bull and North Mocassin Creeks, Tripp County	2,000
Burnt Rock, Gregory County	2,050
Rock Bluff, near St. Elmo, 2,050 up to	2,090
High land, eastern part of Tripp County	2,200
Turtle Butte, south, Tripp County	2,500
Uneroded plain, southwestern Gregory County	2,300
Uneroded plain, west central Tripp County	2,500
Uneroded plain, south of Rosebud Agency	2,800
Uneroded plain, west edge of Rosebud Reservation	3,000

Climate.

In the past few months the author has been asked scores of times, either by letter or interview, concerning the climatic conditions of the Rosebud, and especially Tripp County. Of course, the real aim of the inquiry was as to the amount of rainfall. It is almost universally understood that the climatic conditions, in general, as to temperature, sunshine, etc., are all that are necessary for an excellent farming country. Without quoting government reports as to the maximum, minimum and mean temperatures, and the per cent of days that the sun shines, I will take it for granted that all parties understand that the Rosebud will rank among he most desirable of our South Dakota areas touching the above important factors in a farming community. The all important question is this: Will there be enough rainfall to insure the maturing of crops? All who are acquainted with South Dakota and Nebraska, know that there have been years when the precipitation has been too limited for the best agricultural purposes; nor does one need to be a prophet to predict that these dry years will come again. How soon or how extensive will be these years of too little moisture, when they return, no one can tell. One thing is certain, the farmers can now live comfortably on their land, with no more rain than once fell a few years ago, when men left their lands thinking no crops could be raised. But that was in the days when the farmer had but little, if any, stock, and when he attempted to grow but one kind of crop. Two or three failures were in most cases, sufficient to drive the farmer from his land, or at least compel him to change to some other method of making a living. The plan or system of farming now is much different. Instead of all the land being devoted to wheat, there will be on one quarter section a variety of crops, all of which will very seldom, if ever, be a complete failure. Then in addition to the so-called field crops, there will be numerous kinds of vegetables. These will add much to both the needs of the table and for stock. The more modern farmer, especially on 160 acres of land, will keep a few hogs, cows, horses, besides poultry; all of which will add in a most effective way to the prosperity of the farm. This will be true when field crops are good, but of even greater comparative value will they be in the dry years, when otherwise the farm might be surrendered and the family impoverished for years to come.

There is still another way which is being successfully used, to prevent a failure on the farm when there is too little rainfall—this is called "dry farming." Simply and briefly stated, dry farming means proper methods of cultivation. One of the greatest troubles, as a rule, in a so-called dry district, is not that there is too little rainfall to grow a crop, but that the precipitation is not properly distributed. The greatest trouble comes from excessive evaporation; thus losing the water in the surface of the ground before the time when maturing grain is in most need of water. Dry farming means farming in such a way as to prevent this excessive evaporation. What causes this evaporation? The surface of the soil when allowed to stand for a few days or weeks will of itself form a multiplicity of little pores or openings or capillary tubes, reaching down into the surface far enough to allow large quantities of water to come up to the surface, as water will creep up a porus brick, or any such substance, then when once on the surface, the hot air or warm wind above the ground will cause this water to evaporate as rapidly as it can reach the surface. Let this process continue and as the capillary tubes lengthen in the soil, more and more water will come to the surface, all of which will be evaporated. How can this extensive evaporation be prevented? Any agency will prevent it, which can prevent the formation of the little tubes or pores; or tear them to pieces or destroy them in any way when once formed. This can most successfully be done by frequent cultivation, not deep, but frequent. In crops where there is no subsequent cultivation after seeding time, the best way is to plant the seed in a finely powdered surface soil; in the dust, one might say; this will prevent, to a large extent, the rapid evaporation of the moisture.

There is a very common belief in this section of our country, that the amount of rainfall over any area, increases with more extended cultivation of the soil. In fact it is the well known argument that the belt of extensive precipitation pushes westward at about the same rate as settlements are formed. If the frontier occupied a certain place ten or twenty years ago, and was subsequently moved a hundred miles farther west, as soon as settlers began to plow the land and to raise crops, the rainfall would materially increase in this newly occupied territory. I doubt if any argument, with a certain class of land agents, has been more effectually used in making sales of "wild" land, than the one just mentioned. If such a rule in the increase of rainfall were true, the fact should be known to all. If no such conclusion is warranted, then the people should so understand it. No one, more quickly than the State Geologist, would be glad to inform the people of South Dakota, that after a few years of residence and cultivation, any of our splendid prairie land, would then be in a well watered rain belt.

Data from the Weather Reports of the United States, of South Dakota, of Nebraska, and elsewhere, has been carefully examined to throw light on the subject. One trouble is evident; the time of accurate observation upon the exact amount of precipitation, at most places in this state, has not been long enough to enable one to draw a general conclusion. However, reliable reports from a number of places are accessible. From these the following facts have been deduced:

The average rainfall for Kimball, S. D., for the last sixteen years is 25.69 inches. The minimum falls were: in 1894, 14.40 inches; in 1899, 19.54 inches. The maximum falls were: in 1881, 40.95 inches; in 1875, 37.15 inches. The greatest rainfall in Yankton since 1873 was 40.95 inches, in 1881, over twenty years ago. The least rainfall was in 1889, eight years after the heaviest.

The average rainfall for Kimball, S. D., for the last sixteen years. The maximum was in 1906, reaching nearly 30 inches. The minimum was in 1894, being less than 15 inches. In these extreme years the minimum rainfall was less than one-half the maximum which occurred twelve years later.

The average rainfall for Valentine, Neb., for a number of years is near 22 inches. The average precipitation at Fort Randall, Gregory County, S. D., for the last thirty years, is a little over 27 inches. The average rainfall, since 1892, for Rosebud, S. D., will approximate 18 inches per year. The exact figures can not be given for the reason that no reports are to be found for certain months.

Let me add here that the average temperature of the Rosebud is in summer over 70° and in winter about 30°. The mean average temperature for the year will be between 45° and 50° F.

Special reports are given from: 1. Yankton, S. D., because it is 110 miles east of the south edge of the Rosebud country. 2. Kimball, S. D., because it is about thirty miles east of the north edge of the area. 3. Valentine, Neb., for the reason that this place is only ten miles south of the south edge of Tripp County. 4. Rosebud, S. D., data is used extensively as it is the only station, except Ft. Randall and Fairfax, in the Rosebud country. Rosebud is better than either of these because it is much farther west, and neither in, nor near, a deep valley, as that of the Missouri River.

The following average annual precipitation, for a number of places, not far away from the Rosebud country, are here added to throw additional light on the subject under consideration. The rainfall will be given approximately.

	Inches.
Academy, east of central Rosebud and two miles east of the Missouri River	22
Armour, east of central Rosebud and thirty miles east of Missouri River	24
Tyndall, east of south Rosebud and 30 miles east of the Missouri River	24
Chamberlain, ten miles up the Missouri River from the mouth of the White River	18
Greenwood, ten miles down the Missouri River from Ft. Randall	24
Fairfax, Gregory County	22
Valentine, Neb., thirty miles southeast of Rosebud Agency, and ten miles south of Rosebud Reservation	22
Springview, Neb., fifteen miles south of Tripp County	18

The following tabulation will show the amount of rainfall at the above special named places: Kimball, S. D.; Yankton, S. D.; Rosebud Indian Agency, S. D.; Valentine, Neb. The precipitation for a number of years could not be found nor calculated from any available data. In the case of Rosebud, the rainfall was only reported for a portion of the months in the year, as indicated in the tabulation.

ANNUAL PRECIPITATION IN INCHES

Year	Kimball	Yankton	Rosebud	Valentine Neb.
	INCHES	INCHES		INCHES
1873	.....	.....	....	.....
1874	.....	23.93	....	.....
1875	.....	37.15	....	.....
1876	.....	28.84	....	.....
1877	.....	28.31	....	.....
1878	.....	28.73	....	.....
1879	.....	22.73	....	.....
1880	.....	21.68	....	.....
1881	.....	40.95	....	.....
1882	.....	20.63	....	.....
1883	.....	35.21	....	.....
1884	.....	22.16	....	.....
1885	.....	30.18	....	13.98
1886	.....	29.15	....	12.98
1887	24.65	27.08	....	18.00
1888	12.52	20.89	....	22.64
1889	17.74	19.71	....	19.55
1890	14.08	21.25	....	19.79
1891	24.24	.....	....	27.24
1892	23.17	24.11	23.96 for 9 Months	27.92
1893	17.78	23.32	14.08 for 10 Months	15.69†
1894	8.86	14.40	15.03 for 11 Months	10.14
1895	14.27	23.02	13.00 for 11 Months	
1896	27.42	26.83	20.64 for 10 Months	
1897	25.18	21.76	21.05 for 11 Months	
1898	18.39	21.42	12.67 for 9 Months	
1899	16.39	19.54	11.00 for 10 Months	
1900	20.46	31.38	19.89 for 12 Months	
1901	26.52	24.64†	22.78 for 12 Months	
1902	17.63	32.13*	14.68 for 12 Months	
1903	16.66	31.38	9.06 for 9 Months	
1904	12.32	20.05	13.32 for 8 Months	20.61
1905	21.21	25.46	23.00 for 12 Months	28.37
1906	29.19*	33.21	15.31 for 8 Months	
1907	17.98*	25.71	15.20‡ for 8 Months	16.21
Gen. Av.	23.17	253 .4	18.22	22.46

* 11 months. † 10 months. ‡ Plus.

That there may be a better idea of the annual average rainfall for the states surrounding, or near South Dakota, the following tabulation has been compiled from the Weather Reports of the different states. Also for the same reason a tabulation has been made concerning the average annual precipitation in various sections of the United States.

Average Annual Precipitation in South Dakota and Neighboring States.		Average Annual Precipitation in the Various Sections of the United States.	
States	Av. Rain Fall	Section of U. S.	Rainfall
	INCHES		INCHES
South Dakota.......	20.*	New England	42*
Nebraska	23.33	Middle Atlantic St's	42*
Iowa	34.88	South Atlantic St's.	50*
Minnesota	33.*	East Gulf States....	64*
North Dakota......	18.88	West Gulf States...	48*
Montana...........	13.*	Ohio Valley........	45*
Wyoming	13.35	Lower Lake Region.	35*
Colorado...........	16.*	Upper Lake Region.	32*
Kansas	26.67	Upper Miss. Valley .	34*
Missouri	37.74	Missouri Valley.....	29*
Illinois	38.05	N. slope E. of R. Mts	14*
Wisconsin..........	32.06	Mid. " " " " "	22*
		S. " " " " "	24*
		Southern Plateau R..	11*
		Middle Plateau R...	10*
		Northern Plateau R.	15*
		North Pacific Slope R	52*
		Middle Pacific slopeR	30*
		South Pacific slope R	15*

* Plus.

There is yet another feature of this problem of the amount of moisture, which should be investigated. To say that the annual rainfall is so many inches does not of itself, tell the whole story. A certain locality might have even 30 inches of precipitation and yet not be any better for a crop growing area, than another plain with perhaps not over two-thirds as much rainfall. The important thing to know is, how is the rainfall distributed? In South Dakota we need more or less rain in April, May, June, July and August, the growing and maturing months of the year. It is not at all uncommon to have plenty of rain in the spring, and even in the early summer, but too often this is followed by a series of dry weeks, which largely cause a failure in the maturing of the crops. In order that interested parties may know still more about the distribution of the annual rainfall, the precipitation for the five important months will be found in the following tabulations:

PRECIPITATION AT KIMBALL, BRULE COUNTY FOR THE FIVE GROWING MONTHS.

Year	April	May	June	July	Aug.	Total for 5 Mo.
	INCHES	INCHES	INCHES	INCHES	INCHES	
1886	3.29	0.70	2.55	1.05	2.95	10.45
1887	2.75	0.60	2.05	3.40	10.15	18.95
1888	1.00	4.00	1.77	0.90	2.15	9.82
1889	2.40	1.56	0.72	3.93	1.76	10.37
1890	1.45	2.03	3.07	1.98	2.21	10.74
1891	3.25	0.56	9.28	2.53	2.91	18.53
1892	6.64	4.22	3.58	0.38	2.74	17.56
1893	3.15	3.56	2.65	2.17	0.57	12.10
1894	1.91	0.75	1.36	0.42	0.43	4.87
1895	1.52	1.42	3.49	1.32	1.54	9.29
1896	5.40	1.23	5.60	5.43	2.01	19.67
1897	4.20	1.00	2.52	2.26	2.75	12.73
1898	2.58	3.96	2.26	4.89	1.37	15.06
1899	1.32	2.46	3.13	3.19	1.59	11.69
1900	2.91	1.50	2.40	5.83	4.53	17.17
1901	0.98	1.35	8.42	0.66	4.00	15.41
1902	1.85	1.75	2.39	1.14	3.77	10.90
1903	1.20	2.34	1.73	4.29	1.76	11.32
1904	1.51	1.20	2.16	1.78	2.28	8.93
1905	0.68	6.41	6.99	2.86	0.72	17.66
1906	2.57	6.11	5.07	1.26	6.68	21.69
1907	1.24	2.72	1.85	6.47	1.18	13.46
1908	1.98	4.97	5.36	3.58	3.97	19.86

PRECIPITATION AT ROSEBUD DURING THE FIVE SEEDING AND GROWING MONTHS, WITH TOTAL FOR FIVE MONTHS

Year	April	May	June	July	August	Total 5 Mo.
	INCHES	INCHES	INCHES	INCHES	INCHES	
1892	4.18	5.10	4.48	1.38	4.19	19.33
1893	1.94	2.40	1.69	1.84	0.95	8.82
1894	4.33	0.27	2.50	0.89	1.30	9.29
1895	2.74	1.28	3.99	0.59	0.86	9.46
1896	3.04	0.53		6.63	1.61	11.81
1897	2.87	3.02	1.47	2.50	2.90	12.76
1898	1.41	3.98	0.60	2.77	0.98	9.74
1899	1.31	1.74		1.45	0.77	5.27
1900	2.69	1.03	2.35	6.10	2.32	14.49
1901	2.66	1.54	7.52	1.84	2.75	16.31
1902	1.12	1.87	2.51	1.44	3.08	10.02
1903	2.10	2.41	1.17			5.68
1904	0.60	1.65	4.26	5.30	0.51	12.32
1905	0.68	6.41	6.99	2.86	0.72	17.66
1906	2.84	4.56	1.66	1.01	3.47	13.54
1907	...			5.46	1.07	....

AVERAGE PRECIPITATION FOR MANY YEARS DURING THE FIVE GROWING MONTHS.

Place	County	Apr.	May	Jun.	July	Aug.	Yrs.
		IN.	IN	IN.	IN.	IN.	
Aberdeen	Brown	3.70	2.85	4.38	3.06	3.14	15
Alexandria	Hanson	3.29	3.05	3.77	3.38	2.86	24
Ashcroft	Butte	1.13	2.20	2.84	1.54	1.28	12
Bowdle	Edmunds	2.02	2.18	3.79	2.19	3.00	12
Faulkton	Faulk.........	3.10	1.66	3.75	2.39	2.14	12
Flandreau......	Moody	2.71	3.84	3.87	2.93	3.17	14
Forestburg	Sanborn	2.75	2.52	3.49	2.31	2.15	13
Greenwood....	Charles Mix...	3.14	2.94	3.88	3.52	2.90	11
Huron	Beadle	2.73	2.66	3.67	2.80	2.60	23
Kimball	Brule	2.59	1.90	3.22	2.53	2.71	18
Leslie	Stanley	1.12	1.45	3.30	1.86	2.30	10
Millett.........	Spink..........	2.35	2.25	3.79	2.73	2.62	12
Milbank	Grant	2.21	2.85	3.78	2.62	2.67	15
Oelrichs	Fall River.....	2.12	2.72	3.09	1.99	0.97	14
Pierre	Hughes	2.11	1.59	3.19	2.32	1.81	13
Rapid City	Pennington ...	2.14	2.76	3.59	1.90	1.45	16
Rosebud	Meyer	2.38	2.06	2.96	2.73	1.85	12
Sioux Falls....	Minnehaha....	2.89	4.27	4.05	2.81	2.77	14
Spearfish	Lawrence	2.85	2.99	4.40	2.02	1.71	15
Watertown	Codington	2.72	3.27	3.53	3.47	3.64	13
Yankton	Yankton	3.07	3.84	3.98	3.76	3.06	30

All the above facts have been compiled and given in order that those interested in the future of the Rosebud country and other similar regions of South Dakota, may have all the data accessible concerning the question of moisture in this area. After a number of years of careful observation at many and varied places, we will be better able to answer the question as to the general trend of changes in the amount of rainfall; and if these changes are due to any human agencies. This discussion should not close without a reference to the conclusions reached in other states touching the same inquiry.

Of all the states surrounding South Dakota, none are so able to give us light on this subject as is Nebraska. This is true not only from its proximity and topography, but from the reason that it occupies practically the same rain belts as are found in South Dakota. An examination of a map of South Dakota and Nebraska, showing the rain belts, will represent the following:

1. Belt of near 25 inches of rainfall. The western edge of this belt enters the northeast part of South Dakota and extends in a general southerly direction, down the valley of the Big Sioux, as far as Brookings County; then to the southwest, crossing the valley of the Dakota River in southern Sanborn County; then on through north central Aurora County, across the southwest corner of Brule, the northwest corner of Charles Mix, across eastern Gregory County, entering Nebraska at about the south-central portion of the above county. This belt continues on through Nebraska, in a south and southerly direction, leaving the state through southern Furnas County. The eastern edge of this rain belt lies entirely to the east of South Dakota, except that it cuts through the extreme southeastern part of the state. The east line for Nebraska is found west of the second tier of counties on the east side of the state. These counties are within a still greater area of precipitation.

2. The rain belt of 20 inches, or occasionally a little less, has for its eastern limit the west edge of the 25-inch belt, described above. For its western edge, in a general way, it enters South Dakota in Campbell County and follows more or less directly down the Missouri River to the vicinity of Pierre, when it crosses into Stanley and down into western Lyman County.

From here its western border is a variable one, depending upon the dryness or wetness of the year. However, it in all times swings down through the Rosebud country, and passes on to the south in a much narrower belt through the State of Nebraska.

3. To the west of the above belt is a third rain belt of 15 inches, more or less. This area lies between the above described belt and the Black Hills. As a rule it is very narrow in the southern part of our State, but maintains a good sized width through Nebraska.

Thus we see that there are at least three well defined rain belts common to both states. The Black Hills in western South Dakota, will materially add to the precipitation of that portion of the State, but will not detract much, if any, from areas further to the east. This is true because nearly all the moisture for our rains come from the south and east. Undoubtedly, the Black Hills increase our rains to some extent; as an agency for producing cool currents of air, which meeting the warm moisture laden winds from the southeast, will condense them and thus produce a more extended precipitatioon than would otherwise occur.

Western South Dakota is not at all similar to western Nebraska, yet much of the central portions of the states are quite similar touching the climatic conditions. Because of this similarity, and for the reason that much longer weather and rainfall observations have been made there, than in South Dakota, let us note some of the conclusions reached by the men of Nebraska. These men have been making a study of rainfall; and especially of the question, whether precipitation increases with settlement and cultivation. In Bulletin No. 45, Agricultural Experiment Station of Nebraska, will be found an article on the rainfall of Nebraska, by Messrs. Swezey and Loveland. In this article the question of the change in the amount of rainfall is discussed. These gentlemen have examined the rainfall of Nebraska for about fifty years. They are unable to reach the conclusion that increase of precipitation will follow settlement and cultivation of the land. Speaking of the series of years from 1849 to 1895 they say: "There have been excessively wet and excessively dry years, the annual rainfall having ranged from

13.30 inches to 47.53 inches; there have been groups of wet years and groups of dry years succeeding one another in a rather irregular manner. Thus the forty-seven years may be grouped into periods as follows: The first ten years were mostly wet years, only one of them, viz., 1852, having a rainfall less than normal; the next nine years, 1859 to 1867 inclusive, constituted a period of scant rainfall, including particularly the exceedingly dry years of 1863 and 1864 and the scarcely less dry years of 1859 and 1860; the nine years from 1868 to 1876 inclusive, included years of plenteous and years of scant rainfall succeeding each other in a quite irregular manner; then followed ten years, 1877 to 1886 inclusive, of rainfall generally above the normal; and finally the last five years have been, with the exception of 1891 and 1892, years of deficient rainfall, with the year 1894 the driest of the whole forty-seven.

"But if we divide the entire series of forty-seven years into two periods of twenty-four and twenty-three years respectively, the average rainfall of the first period will exceed that of the last by only about an inch. The first year of the series, 1849, was one of excessive rainfall, not only as shown by the record made at Ft. Kearney, the only station in Nebraska at which records were kept, but also as confirmed by records in the adjacent territories. This difference of a little more than an inch between the mean rainfall of the first twenty-four years and that of the last twenty-three years of the forty-seven would almost disappear if this year of 1849 were omitted from the series; the mean precipitation for the twenty-three years from 1850 to 1872 is 23.55 inches, while that of the twenty-three years since is 23.46 inches.

"The conclusion therefore seems to be a safe one that the average rainfall of Nebraska, although subject to great fluctuations from year to year, yet in the long run remains substantially unchanged, so far as we can discover from the records of nearly half a century."

I would like to suggest to the men who make the weather observations in the Rosebud country, and in fact all western South Dakota, or elsewhere within the so-called dry areas of the State, to note with care not only the rainfall for the growing months, but to investigate the possible variation of the amount of precipitation for the above five months. As suggested in a previous paragraph, the real test of the dryness of any section, agriculturally considered, can not be known simply from the annual rainfall. Only by knowing how much water reaches the surface during April, May, June, July and August, can a correct idea be obtained. The year when the total rainfall registers low, may not be a "dry year," for the farmer, if the loss in precipitation was largely in the late fall or very early spring. In like manner a so-called "wet year" may be too dry for the maturing of an excellent crop, if the increase in moisture should come in the months when the crops were not growing. It is the opinion of the author that it will be found upon careful examination of the long continued collected data, that the percentage of variability in South Dakota will be least for the months when the rainfall is most. If this should prove true, after years of observation, then we will have added one more favorable condition to our facts concerning the climatic conditions of our State. The only one of the five growing months in which the variability may be excessive seems to be that of July, the month when much moisture is needed to develop the growing corn crop.

Another important factor in the consideration of the climatic conditions of any state, or portion thereof, is to be found in the consideration of the spring and autumn frosts. Especially is this true in reference to the Rosebud area. The summer months might have both temperature and moisture sufficient for an excellent general agricultural purpose and yet the late frosts in the spring or the early autumn frosts might destroy the possibility of maturing the crop. The following tabulation will show the time of frosts in or near the Rosebud, compared with other well known localities.

THE LAST AND FIRST KILLING FROST

[Compiled from data obtained from the Climatological Service of the Weather Bureau.] Places near Rosebud Reservation.

Location	County	1904				1905				1906				1907				1908			
		Spring		Autumn		Spring		Autumn		Spring		Autumn		Spring		Autumn		Spring		Autumn	
		Mo.	Day	Mo.	Day	Mo.	Day	Mo	Day	Mo.	Day	Mo.	Day	Mo.	Day	Mo.	Day	Mo.	Day	Mo.	Day
Academy	Charles Mix	4	26	10	22	5	5	10	8	5	8	10	9	5	15	10	11	5	6	9	27
Armour	Douglas	5	14	9	21	5	11	9	4	5	8	10	9	5	26	9	27	5	11	9	26
Chamberlain	Brule	5	14	10	22	5	8	10	11	5	8	10	9	5	27	9	28	5	8	9	27
Fairfax	Gregory	5	14	9	14	5	8	10	9	5	8	10	9	5	27			5	6	9	27
Greenwood	Charles Mix	4	27	10	23	4	21	10	11	5	6	10	9	5	3	10	12	5	8	9	29
Kimball	Brule	5	13	9	21	5	17	10	10	5	8	10	9	5	20	9	28	5	6	9	27
Pierre	Hughes	4	26	10	25	5	5	10	11	5	8	10	9	5	3	10	11	5	2	9	27
Pine Ridge	Shannon	5	17			5	17	9	2	5	9	9	26	5	27						
Plankinton	Aurora	5	14	10	22	5	12	10	10			10	9	5	27					9	27
Rosebud	Meyer	5	18					10	11	5	8					9	10	5	6	9	27
Tyndall	Bon Homme	5	14	9	21			10	11	5	6	10	9								
Yankton	Yankton	4	16	10	23	5	11	10	11	4	15	10	9	5	7	10	12	5	2	9	29
LIST OF PLACES OVER THE STATE																					
Aberdeen	Brown	5	12	9	21	5	12	10	11	5	19	10	5	5	27	9	25	5	2	9	29
Brookings	Brookings	5	14	9	21	5	12	10	10	5	19	10	5	5	27	9	25	5	8	9	28
Canton	Lincoln	5	14	9	21	5	8	10	10	5	28	10	10	5	27	9	26			10	1
Clark	Clark	5	14	9	21	5	25	10	20	5	19	10	5	5	27	9	28	6	10	9	27
Flandreau	Moody	4	26	9	21	5	12	10	10	5	19	10	5	5	27	9	25	5	8	9	27
Highmore	Hyde	6	6	9	14	5	8	10	11	5	8	10	9	5	27	9	28	5	21	9	27
Huron	Beadle	4	27	9	21	5	8	10	11	5	8	10	6	5	20	9	28	5	2	9	27
Ipswich	Edmunds	5	14	9	20	5	27	10	10	5	27	10	5	5	27	9	23	5	22		
Kennebec	Lyman									5	9	10	9	5	8	9	28	5	22	9	27
Milbank	Grant	5	16	9	11	5	1	10	16	5	8	9	30	5	27	9	25	5	6	9	28
Rapid City	Pennington	5	14	9	14	5	6	10	11	5	8	10	5	5	14			5	21	9	27
Vermillion	Clay	4	27	10	16	4	22	10	11			10	9	5	26	10	11	5	7	9	29

TOPOGRAPHY.

GENERAL ELEVATIONS.

In order to get a better idea of the topography of the portion of South Dakota under consideration, the following approximate elevations will be given in addition to the tabulated report on a previous page. Along the eastern part of this area, now Gregory County, is the Missouri flood plain, about 1,250 feet in elevation. Rapidly the land rises to the west, reaching an elevation of 2,000 feet near the town of Bonesteel, as determined by the State Survey levels. Plate III shows a farm scene near Bonesteel on this level plain. Three miles to the west of Bonesteel is "Burnt Rock" rising fifty feet above the plain. This 2,000 foot elevation marks the common uneroded level for miles to the west of Bonesteel. However, there is a gradual elevation to the west of the lands of Gregory County, reaching up to 2,200 feet and even 2,300 feet in the western part. This uneroded plain is confined between the head waters of the tributaries of the Missouri and White Rivers on the northeast and north, and the more gently eroded valleys of the Ponca and Keyapaha and their tributaries on the south.

No actual levels were run by the State Survey farther west than the eastern part of Tripp County, but the author with an aneroid barometer and eye level, estimated the approximate elevation of the more prominent buttes, hills, ridges and plains to the western part of the Rosebud. If you will turn to the map you will note the following tributaries:

I. Of the Missouri, (from south to north).

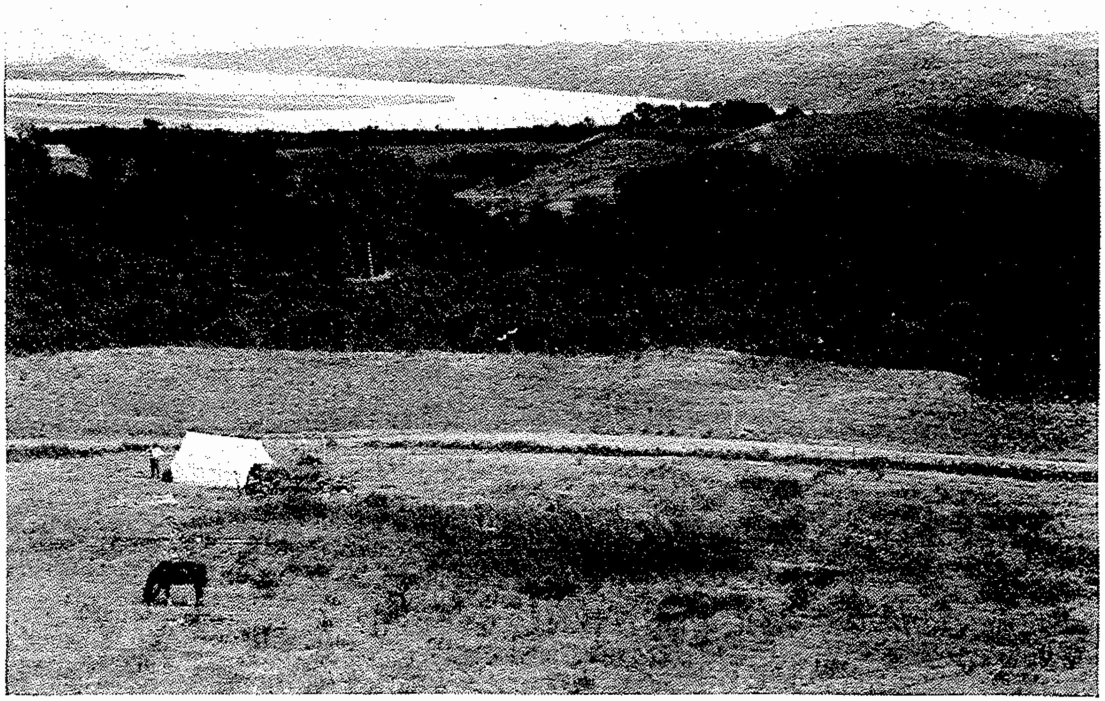
1. Randall.
2. Scalp.
3. Whetstone.
4. Burnt Rock.
5. Landing.
6. Bull.

See Plate VI, showing relation of Whetstone to Mo. River.

II. Of the White River, (from east to west to western edge of Pine Ridge).

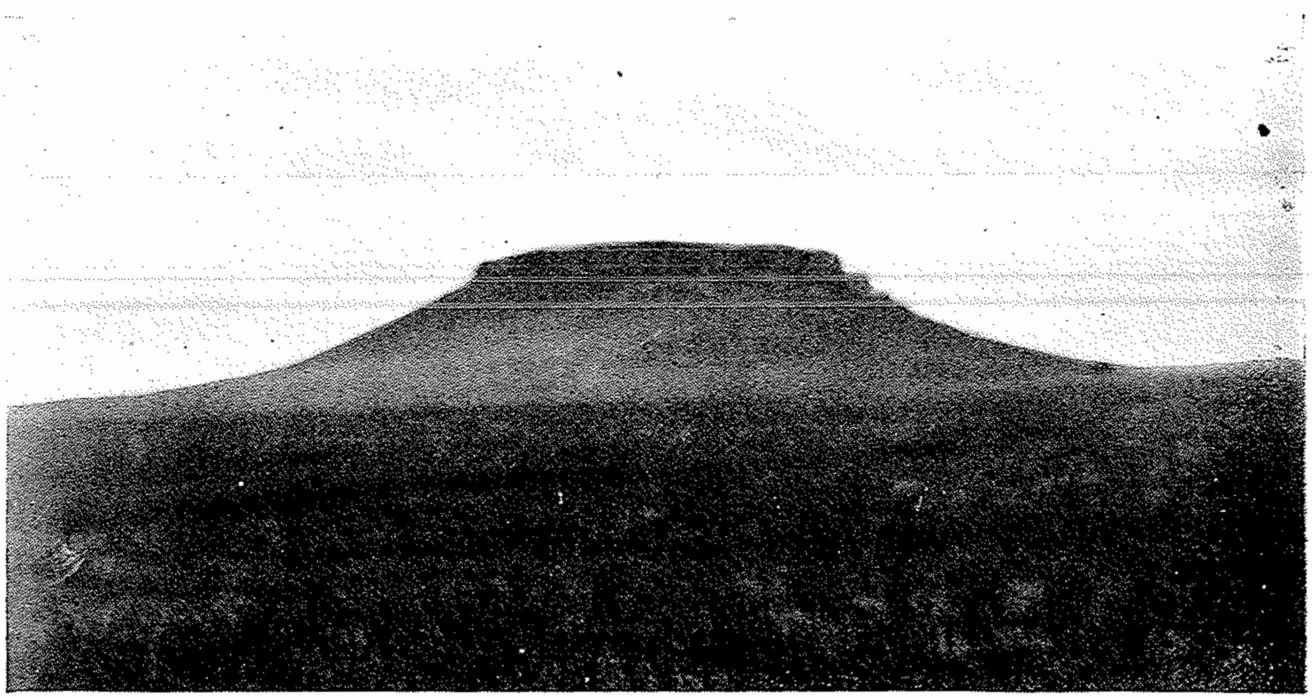
1. Moccasin Creek.
2. Old Lodge Creek.

Plate 6



Missouri River and Valley of the Whetstone

Plate 7



A Butte on the Rosebud Reservation

3. Dog Ear Creek.
4. Cottonwood Creek.
5. Oak Creek.
6. White Thunder Creek.
7. South Fork of White River, or Little White River.
8. Cottonwood Creek.
9. Roundup Creek.
10. Black Pipe, west side of Rosebud.
11. Red Sand, eastern edge of Pine Ridge.
12. Pass.
13. Eagle's Nest.
14. Bear in the Lodge.
15. Corn Creek.
16. Pumpkin Creek.
17. Yellow Medicine.
18. Porcupine Creek.
19. Wounded Knee.
20. White Clay.

III. On the South Side of the Rosebud, from east to west:

1. Ponca Creek, flowing to the southeast and leaving South Dakota in south-central Gregory County.
2. Keyapaha River, flowing southeast and joining the Niobrara a few miles south of Gregory County, but not running through any portion of the above county. Neither of the above streams have any well developed tributaries. Willow Creek, a little west of Turtle Butte in southern Tripp County, is by far the most extensive of the branches.

Thus we have a comparatively level plain gently sloping to the east, cut by a series of minor valleys on the east, north, west, and to some extent on the south. The 2,000-foot level is reached along a general line running to the west, cutting not so far south as the uneroded areas above the head waters of the White River tributaries, but cutting the upper valleys a little beyond the place where the well defined valleys change to gentle sloping draws.

By the same instruments the author estimated that the level plain just above the source of the Ponca, was approximately 2,300 feet; and farther to the west, in what is now Tripp County; between the slightly developed tributaries of the Keyapaha on the south and the eroded area by the creeks of White River on the north, the land reached an elevation of 2,500 feet. The land is quite level, extending much farther west, yet all the while gently rising in elevation until it reaches more than 2,700 feet, as one approaches the valley of the South Fork of White River near Rosebud. By aneroid and eye level the western part of the Rosebud, between the valleys of the South Fork, was estimated to be fully 3,000 feet. To the west, in the Pine Ridge Reservation, the uneroded plain rises at least 500 feet higher. On the high plain above the valleys of Wounded Knee and White Clay Creeks, to the east of Manderson and Pine Ridge, the elevation is at least 3,500 feet.

An easy way to get an idea of the physical features of a land area, is to have the facts brought out by a map showing the streams, valleys, ridges, hills, and uneroded area; along with a few carefully determined elevations. Let it be held in mind that the entire original Rosebud Reservation was, in comparatively recent times a great level uneroded plain, gently sloping to the east. However, not entirely level, for here and there, scattred over its area, are to be found tall flat topped hills, called buttes. (See Plate VII.) These are remnants of still an older plain that occupied this portion of South Dakota in a much earlier epoch of time. This older and higher plain we will not discuss at present, except to say that it was largely destroyed by the work of erosion, just as the present one is being cut to pieces and carried down the rivers to the sea. Nor was this later plain confined to its present limits since its first elevation and subjection to erosion. For a long period of time after the White River had established itself along what is now the northern boundary of the Rosebud, the plain of which this Reservation is a part, extended far beyond the present Missouri River valley. In pre-glacial times the Missouri River occupied the present bed of the James or Dakota River. This being true, the White River must have flowed to the east and emptied into the old Missouri or Dakota River at a point somewhere to the south of the present city of Mitchell.

Plate 8

Modulatory Topography near Ponca Creek

When the great ice-sheet, called the glacier, pushed itself down into what is now South Dakota, coming from a general northeasterly direction, the valley of the old Missouri was entirely obliterated. The new valley of this river was established along the western and southwestern edge of the ice, and there it has remained from that time until the present. Hence that portion of the Missouri River valley in South Dakota above the City of Yankton is "post-glacial" in its origin.

Let it be also remembered that when a valley of erosion is produced it is formed by the water cutting back and up, back and up, until the valley reaches the highest uneroded area. Thus the valleys are all made. However, the almost universal method, is that there will be a series of parallel tributaries sent out from well developed valleys. At first the plain is in its pre-erosion stage, then one great valley as that of the White River is established, and the plain is cut in two; later on, this main river establishes a series of parallel tributaries and that portion of the plain bordering on the larger river is cut into a series of parallel ridges. Later on these tributaries send out their branches and the ridges are cut by these valleys into a series of hills; thus the process continues. At first the plain is all level, then it is sharply eroded down next to the principal rivers flowing through or by it; and as their tributaries continue to work back and up, the surface is more and more eroded until at length there is no level land left. This process will continue until at length the whole area will be approximately the same level as the valley next to the principal river. Should this river empty into the ocean, such an eroded and leveled plain would be called "base-leveled;" but when the main river is only a tributary of still another river, then we might call the leveled plain a secondary base-level. This latter case is nicely represented by the flood-plain of the Missouri River, and the flood-plain of the larger tributaries to this river.

More Detailed Discussion of the Topography of Gregory County.

The topography of the area may be well interpreted from the accompanying map. The rough and broken portions, due to deeply eroded valleys; are to be found along the Missiuri River and its short tributaries on the east, and the larger creeks on the north and northeast. However, much of the land near Bull Creek is like that along the Ponca to the south; quite level, not too rough for farming purposes (Plate VIII will show the undulating topography as it is, near the Ponca. Note the level sky line beyond the local erosion). In the southwest corner of the county near Keyapaha Creek, there is a small portion of hilly or broken land. The remainder of the county, including fully one-half of the entire area, is comparatively level or slightly undulatory. Photograph (a), Plate IX will give the reader an idea of the level uneroded prairie as found in Gregory County, a few miles west of Bonesteel. The carriages in the picture are the rigs of locaters with their home-seekers, all of whom happened to be passing as the State Survey party were running a level along that line. Photograph (b), Plate IX represents the plain as we approach St. Elmo from the east. Note the gentle draws leading down into Willow Creek, one of the tributaries of the Ponca. Plate X will illustrate two views in the Rosebud region, which tell their own story. (a) Represents a well cultivated farm with excellent crops and many home conveniences; (b), a ranch in a slightly eroded area, yet level enough to plow if so desired.

That portion of the central part of the county best adapted for farming is about 800 feet higher than the Missouri River flood-plain. The highest points of the hills and ridges in the deeply eroded areas are approximately as high as the great uneroded central portion. However, most of the hills and ridges have been cut down by erosion until they are now at a lower level. The topography of this area can easily be understood when you know that the Missouri River, flowing through a flood-plain 800 feet lower than the original level of the country, is the main stream of the region, and into this, a number of tributaries are working their way back and up into the great level plateau, cutting it into ridges and hills, which are all the time being eroded lower and lower as the age of the tributaries increase. Of course it is only a question of time, but for the intervention of men, until the area would be cut to pieces by these streams, and none of the original level would be left. There is but

Plate 9

A. On the Level Plateau West of Bonesteel. Elevation 2000 feet. Locating Claims

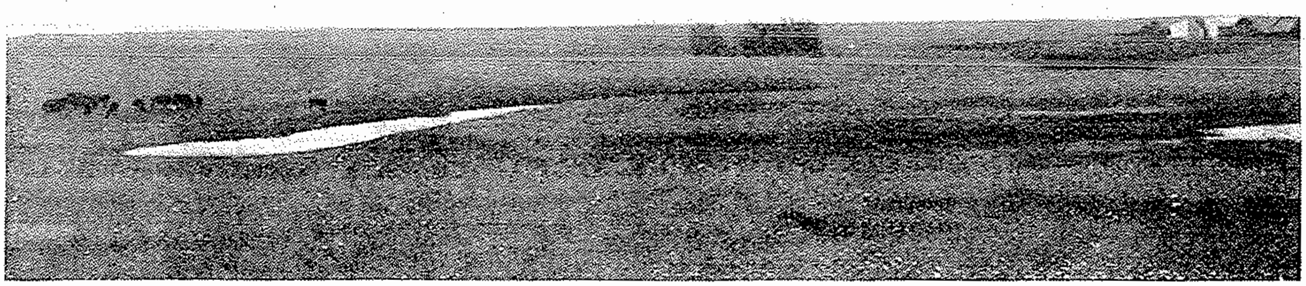
Plate 9

B. Draw of Willow Creek, Just East of St. Elmo

Plate 10

A. A Gregory County Farm

Plate 10



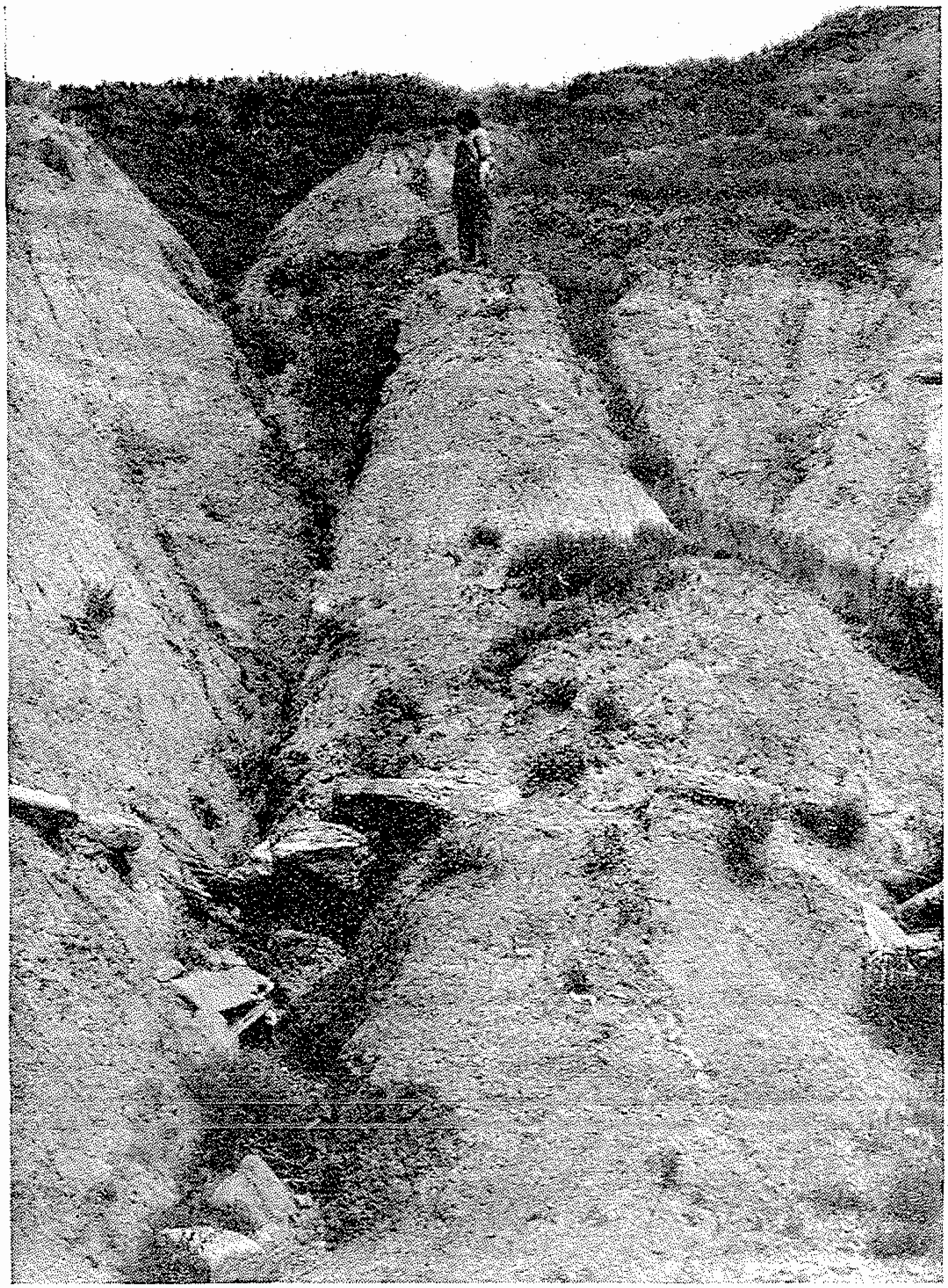
B. A Gregory County Ranch. Virgin Prairie little doubt that the Bijou Hills, 2,000 feet above sea-level in the southern part of Brule County, east of the Missouri River, are but a remnant of the common surface that at one time stretched over all the southern portion of South Dakota. The Bijou Hills are doubtless remnants of the bluff hills that overlooked the pre-glacial White River as it flowed on to the east into the old Missouri River.

The rate of the development of the tributaries of the Missouri River as mentioned above, is due largely to the character of the soils and surface clays. These are, as a rule, loose and easy to erode and wash away. Now and then a hard layer reaches the sarface, as found in places especially along Burnt Rock and Whetstone Creeks in the eastern part of Gregory County, (see plate XI, which shows thick layers of clay with thin layers of rock). Except in small local areas there were seen no glacial deposits west of the Missouri River. These were doubtless due to tongues of ice carrying drift and boulders, which had been pushed further to the west than the main body of the ice. When the glacier ceased to move farther to the southwest, the water which was constantly running from the extremity of the ice, eroded a channel at or near the junction of the ice with the non-glaciated ground beyond; this channel we now call the Missouri River. In a few cases this newly eroded channel did not go around all the farthest extending lobes, but cut through some of them; hence the slight glacial-deposits west of the Missouri River. On the uplands no stones or rock occur except a few outcropping layers, mostly sandstone, in places. These are coarse and occasionally assume an almost quartzitic character; this sub-surface layer of stone is not extensive in quantity, yet it furnishes good foundation stone for many of the buildings, both in the towns and on the farms. Photograph (a) in Plate XII represents some of the outcropping sandstone rock near St. Elmo. This sandstone, in places is a good grade of quartzite, and hence excellent material for foundations or any building purposes. Photograph (b) Plate XII is of the same material as the above, but by its structure not so easily converted to economic uses. This specimen represents in a most admirable way what is sometimes designated "log" structure.

TRIPP COUNTY.

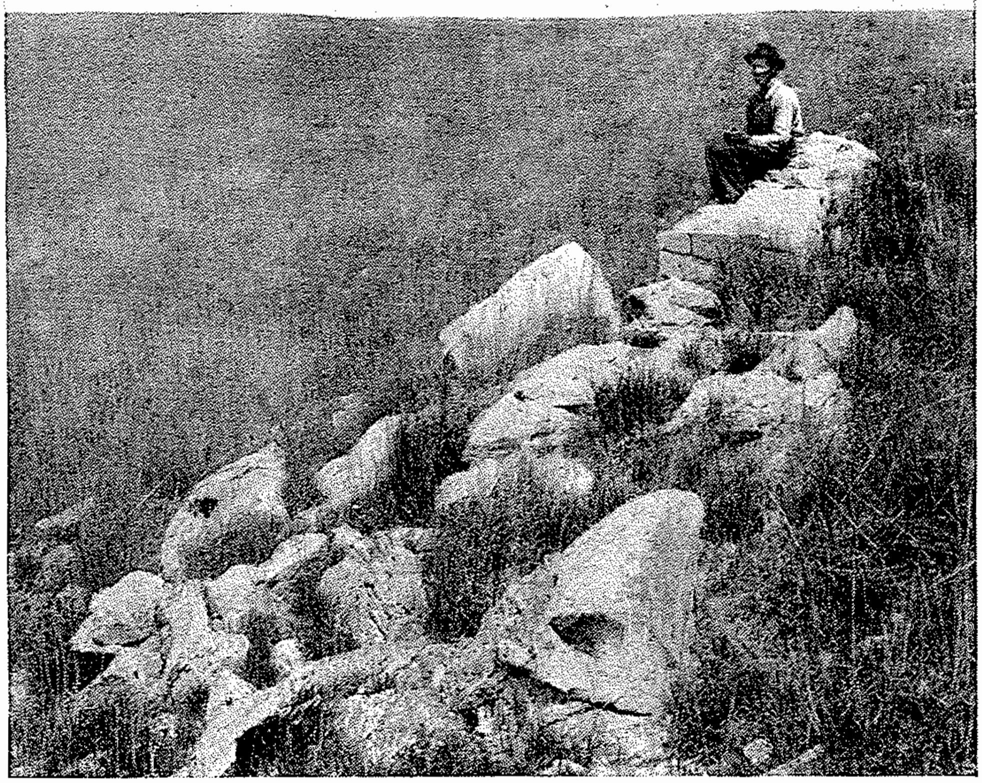
The same general conditions determining the topographic features in Gregory County, will apply in Tripp County, and in fact all the Rosebud territory. The central and southern portions of the county are largely free from erosion forms, and hence, are comparatively level. A little south of the central-western part of the county is to be found the highest land, reaching an elevation of about 2,500 feet. From this high area the land slopes in three directions: 1. To the south into the valley of the Keyapaha with a fall of 250 to 300 feet. However, the topography is not nearly so uneven as it would have been, had there been formed a number of well developed tributaries running into the Keyapaha. The branches of the Keyapaha are few and poorly developed. In the south-central portion of the county stands Turtle Butte, 250 feet above the valley. This, like other such formations, is but a remnant of an older plain, left, as it were, to indicate the elevation of a former surface. Turtle Butte is about the same in elevation as the highest land of the county. Its existence is due to a slightly harder surface cap which did not yield so easily to erosion as the surrounding area. 2. To the north and northeast extending on to the upper valleys of Dog and Old Lodge creeks, and on down to the valley of White River, over 750 feet below. The fall in surface is about 250 feet by the time the upper well defined valleys of the creeks are reached. Thus we see that the White River valley in the north is fully 500 feet lower than the valley of the Keyapaha on the South. Here is to be found the principal explantion why the Keyapaha has such a paucity of well developed tributaries. 3. To the east; a long gentle slope toward the headwaters of the Ponca, so gradual is the decline that not until Gregory County is entered, has the fall reached as much as that experienced in going less than one-half that distance to the north. Except for the lowest portions of the valley of the Ponca, one would have to go on to the central part of Gregory County to get the above fall of 250 feet. The map will show that the north side of the county is badly cut up by four well developed creeks, Bull, No Moccasin, Old Lodge and

Plate 11



Exposure of layers of hard clay and thin rock
Eastern Gregory County

Plate 12



A. *Outcropping Sandstone near St. Elmo*

Plate 12

B. *Outcropping Sandstone near St. Elmo*

Dog Ear. These practically parallel streams have all worked back and up from the valley of the White River, 1,500 feet in elevation, up to the general surface of the county. And in doing so they have cut the surface down so that in following up these streams a distance of 15 to 20 miles, on a straight line, you will rise on an average about 25 feet per mile, until you reach the uneroded plains 500 feet above the mouths of these creeks.

No such inequalities are found on the south or east side. While to the west, as we enter the present Rosebud territory, the land continues to rise gently until it reaches an elevation of more than 2,700 feet, as we approach the bluff along the south fork of White River.

THE PRESENT ROSEBUD RESERVATION.

The topography of the Rosebud Reservation, as it now stands, is much more variable than that of either Gregory or Tripp Counties. The lowest level is in the extreme northeast corner, in the valley of the White River. Here the elevation does not exceed 1,500 feet. The hightest point is in the southwest portion of the area, where the elevation is fully 3,000 feet Thus the waters of the south fork of White River in flowing from their high sources into the White River, fall, in crossing the reservation, one half of the way to the sea. This of itself is an interesting feature in the topography of the Rosebud.

The cutting of land by erosion is more generally developed in the Rosebud proper, than in the eastern portion as seen in Gregory and Tripp Counties. This is true largely from the reason that the south fork of White River, a stream approaching in size that of the main river itself, leaves White River as a tributary in about the central part of the north side of the reservation and cuts back and up and almost through it. Leaving the reservation in the southwest corner, this south fork has a number of well developed creeks or tributaries; such as, Horsehead, Dry, Soldier and Rosebud on the east side, and with Pine, Cut Meat and Tiskermed, west tributaries. The north side of the reservation is well eroded by a series of tributaries of White River, like those seen in the counties to the east. The most important of of these creeks are Oak and White Thunder, to the east of the South Fork, while on the west are Cottonwood, Roundup and Black Pipe creeks. Because of the above facts the least eroded portion of this area is in the southern part of the reservation, even though the Keyapaha with its tributaries are found in that portion of the Rosebud.

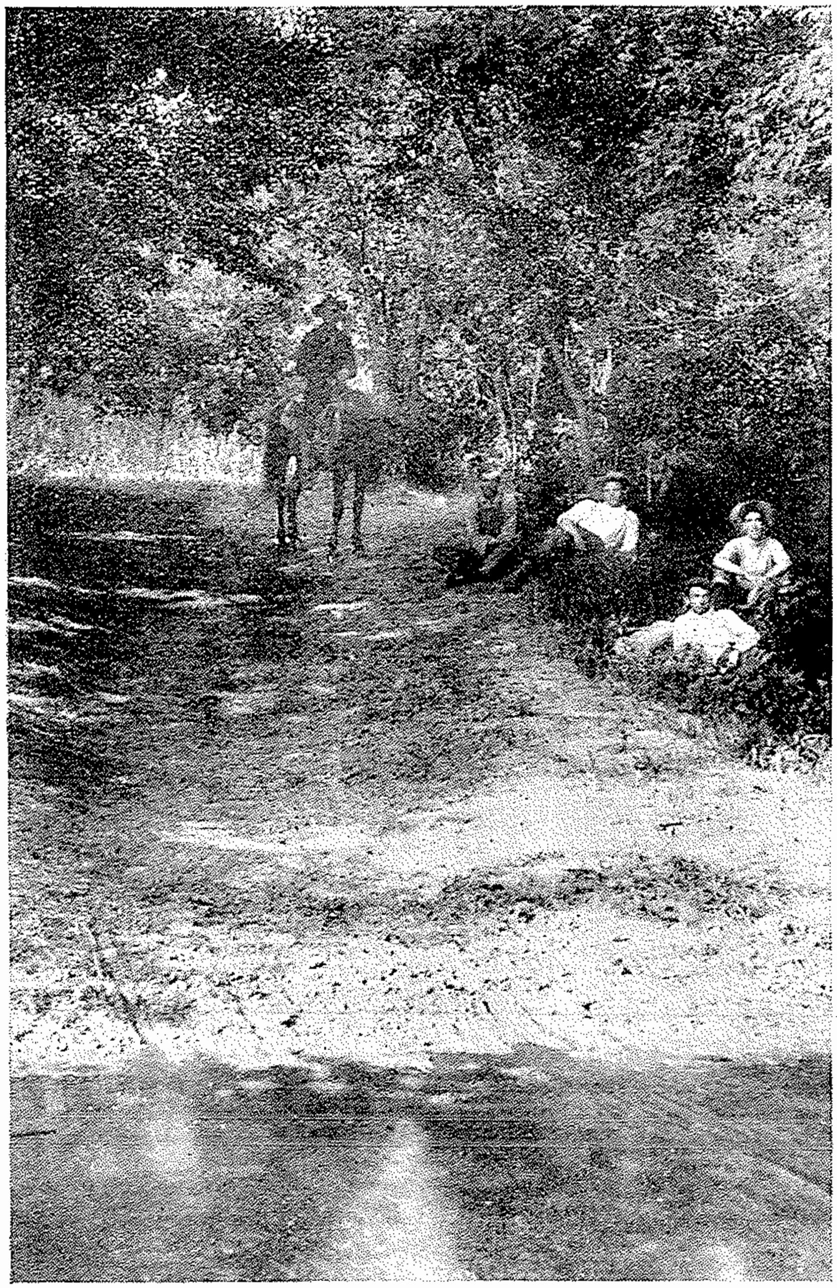
Drainage

Three main rivers determine the direction of the drainage of this entire area: 1. The Missouri, which is the exceptionally euphonous way the Indian had for saying what the white man means by the expression "Big Muddy." 2. The White River, so called because of its color, especially during the rainy seasons. The white is fine sediment, held in suspension, from the Oligocene clays of the Bad Lands. 3. The Niobrara, an Indian word for "Running Water."

The general drainage of the Rosebud Reservation can easily be inferred from the map. Had this reservation extended a few miles into Nebraska, then it would have been bounded on the three sides by prominent streams, White River on the north, Missouri River on the east, and the Niobrara on the south. Inasmuch as the Rosebud does not extend beyond the South Dakota line on the south, it is only eroded by the northern tributaries of the Niobrara. These are the Ponca, the Keyapaha and very slightly by the Minnachaduza. Much concerning the location and character of the first and second have already been given in the preceding pages.

One of the most interesting features of the drainage of the Keyapaha is found in its relationship to Antelope Creek, which now forms the headwaters of the Keyapaha. In its early history, the Antelope was doubtless the upper course of Little Oak Creek, a minor tributary of the South Fork of White River. Later on an act of piracy in stream erosion, was accommplished by the Keyapaha tapping the channel of the Little Oak and robbing it of its water. This will explain why the upper course of the Keyapaha is a stream flowing at almost right angles to the general direction of the river. Also why the Little Oak is now practically without water. The big bend in the Antelope and the wind gap, representing the location of the old Little Oak are evidences, as Mr. Reagan once suggested, tending toward the above conclusion. Still more interesting is the probable future

Plate 13



Along the Ponca

of the upper course of the Keyapaha. A glance at the map will show that Oak Creek and White Thunder Creeks are working back at almost right angles to the above river. But this is not all, the White River tributaries are much lower than the valley of the Keyapaha. Then to the above must be added the additional facts that the Oak and White Thunder Creeks are flowing in valleys steeper in gradient than the river on the south; and all are in a more or less sandy stratum, the Tertiary, which is easily eroded. It will be only a question of time until these streams working back from the north will tap the Keyapaha. White Thunder Creek is now within about four miles of Antelope Creek and working back in a channel 100 feet lower than the above stream. It is not an uncommon thing for one stream to rob another of its water, but the above case with its almost certain future, is exceptionally rare, with its double act of piracy. First, a stream from the southeast, tapped a stream flowing north; then later a valley from the north will work back and enact a greater robbery than the southeast stream accomplished, and do it upon the original pirate.

The Ponca, like the Keyapaha, has its source in the Tertiary and as a result the water, like that of Antelope Creek, is clear and excellent for use. These streams are in many places exceptionally attractive as the accompanying photograph will indicate (Plate XIII.)

The most striking condition in the drainage of the Rosebud and its immediate environment is to be found in the fact that the tributaries of the White River are practically all from the south side. Earlier in this article will be found the names of the creeks flowing into the White River from the south; not one such tributary can be mentioned, coming from the north, even from the Missouri River on the east to the Bad Lands on the west. The explanation is found in the different geological conditions of the two sides. On the north the surface formation is largely Ft. Pierre Shale, a part of the Cretaceous; while on the south, above the Pierre Shale, is to be found the Tertiary. Both the Oligocene and the Loup Fork formations of the Tertiary, are much more easily eroded than the Cretaceous Shales. The above facts make the southern tributaries of the White River interesting for the reason that they are now building up their middle courses with the Tertiary sand, which is easily eroded and carried down stream until the lower gradient of the channel is reached, there deposition follows at once. The result is that while the upper courses may have water in the valleys, much, if not all of the year, the middle portions will be comparatively dry at all seasons except the rainy ones; the waters from the higher and steeper courses reach the lower gradient and there sink into the sand previously deposited. Only during the flooded stages of the valleys, are these streams able to carry the sand to the channel of the White River.

Every well developed stream has three courses, the lower, with a low gradient; the middle, with a gentle gradient; the upper, with a steeper gradient for its channel; all these are well represented in these tributaries of the White River. Any well loaded stream will begin to deposit its sediment as quickly as its velocity is checked. *The carrying power of running water varies as the sixth power of its velocity.* Two things will determine the velocity of a stream—its gradient and its volume. As soon as either or both decline the stream ceases to be able to carry its load, and deposition at once takes place. As an illustration of the above conditions and principles, take White Thunder Creek; the lower course is at an elevation of about 1,700 feet, the source is near 2,400 feet. Within a distance of five miles from the head waters this stream falls 300 to 400 feet, thus leaving a fall of only 200 to 300 feet for all the remainder of its course. The same thing is true of Oak Creek and other near by tributaries. If the underlying shale were as easily eroded as the sandy formation above, then this special feature of the drainage of these White River tributaries would not exist, as we find it at the present time. The ease with which the sandy layers of the Tertiary are eroded adds to the rapidity with which the higher surface area is removed, thus lowering the surface of the country more rapidly than had its highest layer been a formation less easily removed by water. Had the sandstone deposits been below the less easily eroded shale, then these tributaries would have had a tendency to form rapids or little water falls at the junction of the shale with the easily eroded sand below.

WATER

The water of the Rosebud may be easily classified into that coming from streams, springs and wells. Of the streams much has already been said. The principal springs of the area are to be found at the junction of the Tertiary and the Cretaceous; or at the base of the Loup Fork as its rests on the Oligocene. However, in the eastern part, in Gregory County, a number of good springs are found at the out-cropping sandy formation, a few feet below the general surface of the county. The best springs, as to the character of the water, are those from the base of the Loup Fork. Perhaps the poorest water is from those coming from below the Oligocene clays. These are apt to be not only alkali, but also clayey in taste. When the smaller streams are at all permanent in their flow it will be found that they usually, if not always, have their source in a number of springs. This means that as these streams have eroded their valleys back, at first, during the rainy seasons, they at length tapped the porous stratum containing the underground water, and thus the springs were formed. Inasmuch then as the springs are the source of the permanent streams, the character of the water in the stream will depend upon the nature of the spring water.

To the prospective farmer of this region the most important supply of water must come from the wells. These may be divided into two general classes, shallow wells and deep wells.

SHALLOW WELLS.

On the higher land in Gregory and Tripp Counties, the shallow wells are, as a rule, from 20 to 100 feet in depth, a few are deeper and more shallow than the above estimate. The supply of water comes from a sandy layer varying somewhat in its position at different parts of the area. The following data will show the type formation for these wells. The first one, that of the shallow; and the second that of the deeper ones.

1st.	Feet.
Soil	2
Clay	20

Sand	2
Total depth	24
2nd.	
Black loam	4
Clay	2
Sandy clay	12
Clay	73
Sand	15
Total depth	106

Further to the west excellent wells may be had at shallow depths, in the sand formation of the Tertiary.

Deep Wells.

The source of all the artesian wells, whether they are flowing or not, is the same in Gregory County and all the Rosebud area, as elsewhere in South Dakota. The Dakota sandstone, a sub-division of the Cretaceous, is the porous stratum from whence the great supply of water for our deep and flowing wells has its origin. This Dakota sandstone lies approximately 600 feet below the surface of the Missouri River bottom. It is about 1,200 feet below the surface on the high plains of Gregory County. While on the uneroded levels of Tripp County it would be as much as 1,500 feet below. And on the high divides between the White and Keyapaha Rivers in Meyer County, it would not be nearer the surface than 2,000 feet. On the still higher lands southwest of the Rosebud Agency this sandstone would doubtless, be as much as 2,500 feet below the surface. Only in the Missouri River bottom, and some of the deeper valleys of the tributaries of the above river, will flowing wells be found. The oldest artesian well of all this region is the one at Ft. Randall. This well was drilled by the government, the log of which is as follows:

	Feet.
River alluvium, clay, gumbo, etc., down to	100
Shale, soft in character, Ft. Benton, down to	460
Sandstone, water-bearing, Dakota sandstone, down to	520
Shale, blue in color, rather soft, down to	576
Hard rock, quartzite or granite, down to	610

If the above data is correct, then at Ft. Randall the Benton shale is 360 feet in depth. This is almost an average depth for the Benton formation, not only in the Rosebud territory, but also as found in many other parts of South Dakota. The Niobrara and Pierre formations are above the flood plain of the Missouri River in eastern Gregory County. The surprising part of the above section is the position of the Dakota sandstone. This water-bearing stratum was seemingly reached at a depth of 460 feet below the level of the flood plain, which is 250 to 300 feet nearer the surface than one would expect to find this sandstone layer; judged by other deep wells not only in the bottom, but east of the Missouri River. Strange again, is it that there is about 50 feet of soft shale below the sandstone which is directly on top of what is generally supposed to be either massive rock or Sioux Falls quartzite. At some places there is found a layer of sand in the Benton group, but at no place, as far as the author knows, has this Benton sand produced such a copious flow of water as that found in the Ft. Randall well, reaching as much as 600 gallons per minute. It is possible that Ft. Randall stands over a ridge or hill of Sioux Falls quartzite; yet this gives no explanation why the Dakota sandstone should be so near the surface at this place. Darton thinks (Geology and Underground Waters of the Central Great Plains, pp. 231) that the above record is a very inaccurate one, touching the genral facts as to thickness, depth and character of the rocks penetrated by this well.

The average depth of the flowing wells in the Missouri River bottom is 800 to 900 feet; and those in the valleys of the tributaries of the Missouri River, as that of the Whetstone, are much the same. No flowing wells are found in this territory except in the areas mentioned above. Near Dallas there is a deep well about 1,500 feet in depth. This penetrates into the Dakota sandstone for nearly 100 feet; the water rises to within 200 feet of the top. At Fairfax and other places there are wells similar to the one at Dallas.

The most noted of all the deep wells of the entire reservation area is that known as the Rosebud well. As much as twelve years ago the government, through its Indian Department, began the drilling of an eight-inch well on the high uneroded land near Oak Creek. This area constitutes the divide between the tributaries of the White River on the north and the drainage of the Keyapaha on the south. The well was not completed, or abandoned by the drillers in 1897, nearly two years after it was begun. Many wish that the drilling had continued to a lower depth. The object of the well was to furnish plenty of water for this part of the reservation and also to supply neighboring valleys with constant streams. The elevation of the surface of the well has been determined by the United State Survey to be 2,626 feet. The depth of the well is 2,500 feet; the water rises to within about 500 feet of the surface. Hence, had the surface of this portion of the Rosebud been only 2,000 feet, instead of 2,626, the Rosebud well would have been a strong flowing one. It is worth much to this section of the State to know what may be expected from deep well borings, even into the Dakota sandstone. If the pressure should remain constant and other conditions the same, no flow of water might be expected if the surface were 2,000 feet or more above sea level. However, for lower levels a flow may be expected. The probabilities are that the Dakota sandstone is not to exceed 1,800 to 1,900 feet below the surface of the White River valley, even in the northwest part of the Reservation. If this is true, and if the same pressure holds there, as is found in the Rosebud well, then a flow might be expected almost any place in the valley of the White River up to the northwest corner of the reservation; also flowing wells should be obtained in the deeper valleys which are tributaries of the White River. It should be clearly remembered that as a rule the pressure on the underground artesian water supply increases as we go west and decreases toward the east.

NOTE.

Few more important topics of an economic character are now before the people of South Dakota than the one involved in the preservation of our Artesian Water Supply. Only a limited amount of water can get into the Dakota Sand stone, at or near its out-crops, in the region of the Black Hills. No more water can be taken out than enters this Sand stone. If we draw off, through our Artesian wells, more water than enters this porous stratum, then the supply as well as the pressure will be diminished.

Evidently this is what our state is doing at the present time; as may be seen in the decreased flow and pressure in many places. South Dakota's Artesian well basin, with its water, is a great natural resource which should be carefully conserved for the benefit of the next generation. For a more extended discussion see other articles by the author.

The following section, showing the depth of the Rosebud well, the different geological formations penetrated, along with something of their character, has been determined from the government report of the well. The well is cased in 8-inch pipe over 2,100 feet, and then 6-inch pipe the remainder of the way. The main supply of water comes from near 2,300 feet.

Depth	Thickness	Character	Age	Divisions
FEET	FEET			{ 2 Arikare
0– 350	350	Sand, Clays, &c.	Tertiary	{ 1 White Rv
350–1550	1200	Shales, dark green &c	Cretaceous	Ft. Pierre
1550–1750	200	Chalk Stone, Shale &c	Cretaceous	Niobrara
1750–2100	350*	Shales, dark with sand	Cretaceous	Ft. Benton
2100–2500	400*	Sand stone with shale layers, ss, porous & water bearing.	Cretaceous	Dakota Sand Stone

* Plus

In addition to the above general sources of water for the Rosebud Reservation, there may be added the following: water holes, ponds and lakes, none of which are of great importance except where springs and wells are not convenient or have never been formed. The water holes, not common, are generally artificial ponds, made by placing a dam across a draw so as to hold the water when the snow melts or when the rains come. Only when the formation beneath the surface soil is an impervious clay can these water holes be successfuly used. On much of the surface the conditions are too sandy for such a means of water supply. Ponds or small lakes exist in a number of places, due to an irregular surface. Some of these have water in them all the year and prove a most convenient source of water for stock and not infrequently for man. In many places sink-holes exist; these do not retain the water which flows into them, but a very short time. The water soon percolates through the porous stratum and manifests itself again as springs at the lower outcropping ledges in the valleys. The sink-holes have their origin in those places where there is an underground drainage. A well defined stratum of the Oligocene formation is a limestone layer, porous in many places; also one of the layers of the Arikaree is a very porous sandy stratum. These porous layers constitute the cause of the sink-holes.

GEOLOGY

The geological formations which can be seen or have been more or less studied and investigated, in the Rosebud area, extend from the Dakota of the Cretaceous up to some of the layers of the Loup Fork or the Arikaree of the Tertiary. The highest layer the Loup Fork is found on the highest elevations as Eagle Nest Butte at an elevation of over 3,500 feet above sea level, or more than 2,200 feet above the Missouri River flood plain on the east side of the Rosebud.

As stated in a previous paragraph, the Dakota sandstone is approximately:

500 feet below the Missouri River.

1,200 feet below the higher lands of Gregory County.

1,500 feet below the high plains of Tripp County.

2,100 feet below the surface at the Rosebud Artesian well in Meyer County.

Doubtless farther west on the still higher lands, the Dakota sandstone would be found much deeper below the surface. Hence there is more or less known about more than 2,500 feet of rock formation included between the lowest and the highest strata. Just what the formations are below the Dakota sandstone, is a conjecture based on what we know exists elsewhere. This must be somewhat modified by what is found at the base of the Ft. Randall well in eastern Gregory County. The log of this well is found on a preceding page. This section shows that at near 600 feet below the surface, a very hard rock was struck—some think this rock to be granite, while others believe it to be quartzite. Mr. Darton believes this formation to be quartzite (Geology of the Great Plains, p. 119). All things considered, it would seem most likely that this idea is correct.

The following tabulations of the rock formations found in the Rosebud will give an idea as to their relationship, thickness, position in geological scale, etc.:

Eras	Ages	Divisions	Sub-Divisions		Thickness
					UP TO
Cenozoic	2 Quaternary	Pleistocene	Glacial	[Not found]	
		4 Pliocene	Equus Beds	Ogalalla [Not found]	
	1 Tertiary	3 Miocene	Loup Fork Beds	2 Arikaree	100ft*
				1 Gering	
				3 Protoceros or River sands	300 ft
		2 Oligocene	White River Beds	2 Oreodon or Brule	
				1 Titanotherium or Chadron	
		1 Eocene		[Not found]	
Mesozoic	4 Laramie			[Not found]	
	3 Montana	2 Fox Hills		[Not found]	
		1 Ft. Pierre			1200 ft
	2 Colorado	2 Niobrara	Chalk Beds		200 ft
		1 Ft. Benton	Shale Series		350 ft
	1 Dakota	Sandstone	Water Bearing Series		400 ft

* Plus

THE DAKOTA SANDSTONE is the porous waterbearing stratum of this area. Its thickness under the Rosebud surface is not well known, but it will doubtless be found to be from 100 feet to 400 feet, more or less. In the Ft. Randall well the data shows only 60 feet of real sandstone, while in the Rosebud well the Dakota sandstone seems to be from more than 260 feet to more than 400 feet, depending upon the horizon where the Dakota is supposed to begin. In an estimation it must be remembered that the well does not reach to what is thought to be the bottom of this sandstone formation. It would have been much better had the boring continued until the bottom was certainly reached.

In the counties to the east of the region, beyond the Missouri River, the Dakota sandstone has been found to be, in:

Charles Mix County, more than 200 feet.
Bon Homme County, as much as 500 feet.
Yankton County, up to 500 feet.
Brule County shows records up to 300 feet.
Aurora has as much as 300 feet.

It is well established that the Dakota is not a homogeneous layer of sandstone. Between the sandstone layers there are intervening beds of clay or shale material. These intercalary like beds make it difficult in many cases to determine the exact limit of the real sandstone stratum.

THE BENTON OR FORT BENTON SERIES OF SHALES are statigraphically above the Dakota sandstone. In many places in South Dakota the series have been divided into three formations named: Carlile, largely dark shales, Greenhorn, mostly thin beds of limestone; Granerous, chiefly shale with some sandstone. In the Rosebud country the formation has not as yet been studied, by deep borings, enough to differentiate it into the above characteristic beds or divisions. The Benton in thickness does not differ much from the Dakota. The following data will give its varying depths in and near this region. This data is taken from the sections of the different deep wells.

	Feet.
Rosebud well	350
Gregory County	360
Charles Mix County	350

Plate 14

A Gregory County Farm. Level Fertile Plain

Bon Homme County	400
Yankton County	300
Brule County	500
Aurora County	300
Douglas County	350
Hutchinson County	400

THE NIOBRARA.—The chalk or chalk and limestone formation occupies the position between the Benton below and the Pierre shales above. It varies both in character and thickness. It outcrops in well defined layers along the banks of the Missouri River in eastern Gregory County. It is always in striking contrast with the shales which are found either above or below the ledges of light bluff colored chalk. This calcareous formation along with the siliceous shales, constitute the material from which the excellent and well known Portland cement of Yankton is made. This fact shows its possible economic value. Some idea of its amount may be gained from the following data as to its thickness in different places:

	Feet.
Rosebud well	200
Bluff of the Missouri River in Gregory County ....50 to	75
Charles Mix County	300
Yankton County	
Brule County	200
Aurora County	150
Douglas County	100
Hutchinson County	300

PIERRE SHALES.—On the eastern edge of Gregory County, next to the valley of the Missouri, the Pierre or Ft. Pierre shale outcrops as the deposit which overspreads the Niobrara chalk beds. The Pierre shales form, in the main, the surface of Gregory County, as well as the entire northern half of the Rosebud territory. It must be remembered that shale, when exposed, easily goes into *clay,* and clay, when fertilized to the point of productiveness by vegetable matter, or by any means, becomes *soil.* Plate XIV will indicate how fertile this soil may become. The Pierre beds in many places were never, apparently, very well compressed into hard shale. Hence this formation goes all the easier into clay. Plate XV shows the eroded Pierre shales above the Missouri River flood plain. Much of our so-called "Gumbo" is Pierre shale decomposed or altered into clay. In the Rosebud well, the Pierre series is nearly 1,200 feet in thickness. The area where the Pierre forms the surface may be stated, in a general way, for the counties now comprising the Rosebud Reservation, as follows: Gregory County, all except the high hills in the northern part and the southwest portion of the county. In this latter area, however, the Ponca has cut through the Tertiary beds and has made a wide valley down the Pierre shales. Tripp County, with the exception of a few hills, all the northern and central portions of the county as far south as the high divide beyond the headwaters of Bull, Moccasin, Old Lodge, Dog Ear, and Cottonwood Creeks. This high plain above the Pierre is composed of Tertiary beds, which extend for twenty miles to the south edge of the county, except where the Keyapaha has cut into the Pierre, just as the Ponca in Greogory County. Meyer County—The same general conditions prevail in Meyer, as in Tripp County; the creeks running into the White River; Oak, White Thunder, and the South Fork of White River, with their tributaries, have eroded away nearly all the Tertiary deposits and left the Pierre shales exposed. The above creeks have not as yet, cut their way back quite as far as have the streams of Tripp County. However, a larger per cent of the surface of Meyer County is Tertiary, than is found in Tripp County. The bed of the South Fork of White River leaves the Pierre shale some ten miles to the north of Rosebud Agency. The Pierre shale is exposed in the bed of the Keyapaha in the southeastern part of the county.

THE TERTIARY.—No doubt that at one time the Tertiary beds covered not only the entire Rosebud Reservation, but went far to the north of White River, as they also did to the east of the Missouri River. As proof of the above, such Buttes as White Clay, Medicine and others, bear witness that the Tertiary was once north of the Rosebud; while such hills as the Bijou, Wessington and Ree Heights, are the monuments over Brule, Jerauld and Hand Counties; that the Teritary formation once formed the

Plate 15

Missouri River. Eroded Ft. Pierre Shale in Background surface layers. The present distribution of the Tertiary in the Counties of the Rosebud area, can easily be determined by the above discussion of the Pierre shales. The part not covered with Pierre shale, is overspread with the Tertiary.

The geological areas, ages, etc., tabulation on a preceding page, will show the divisions into which the Tertiary may be divided. In this discussion the Tertiary may be considered as comprised of simply the White River and the Loup Fork beds, the former being certainly Oligocene while the latter may be Miocene, but certainly Arikaree. The White River or Oligocene beds are composed in the most part of clays or soft-like shales, rather light in color and nearly horizontal in position. Some sandy layers are present, and occasionally banded layers with more or less iron, are found. These White River beds lie unconformably upon the Pierre shales. The Arikaree Series, largely sand and sandstone, in formation, lie unconformably upon the White River beds. Great variety is found in the Arikaree layers. Some are almost quartzite like in hardness and compactness; others are a sandstone with a calcareous cementing agent; while some beds are more compact than cemented together. Some idea of the thickness and character of the Tertiary beds may be obtained from the Rosebud well section, and from the following sections, some of which data was obtained through the kindness of Mr. Raegan.

As soon as the author has an opportunity he wishes to again visit the Rosebud area with the idea of being able to determine more clearly the entire geological history and lithological relationship, and possible economic value, of the various formations making up the exceptionally interesting series of the Rosebud rock layers.

SECTION ON WEST SIDE OF OAK CREEK.

Depth	Thickness	Character	Geology	
FEET	FEET			
0 to 10	10	Clays, light colored.	Tertiary	Oligoeene
10 to 16	6	Gravels	Tertiary	Oligoeene
16 to 22	6	Clays, light colored.	Tertiary	Oligoeene
22 to 26	4	Gravel stratum......	Tertiary	Oligoeene
26 to 146	120	Shales, dark........	Cretaceous..	.... Pierre

SECTION IN VALLEY, SOUTH SIDE OF LITTLE WHITE RIVER

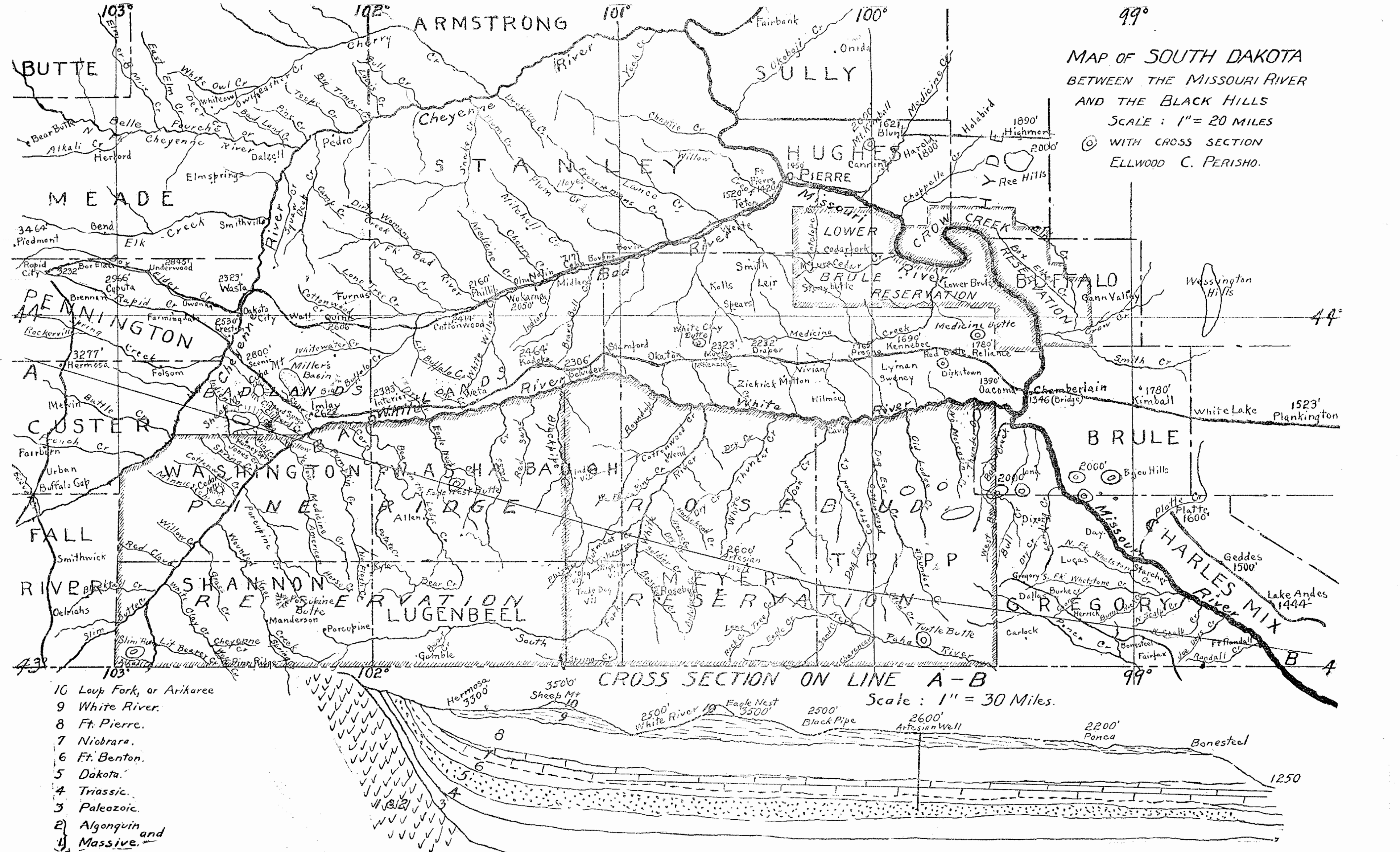
0 to 1	1	Black earth, recent.	Cretaceous..	....Pierre
1 to 21	20	Gravels and sands..	Cretaceous..	....Pierre
21 to 31	10	Clays, light	Cretaceous..	....Pierre
31 to 43	12	Gravels & sand bed'd	Cretaceous..	....Pierre
43 to 53	10	Clays, ...	Cretaceous..	....Pierre
53 to		Shale, dark.........	Cretaceous..	....Pierre

SECTION 1 MILE S. E. OF WHITE THUNDER DAY SCHOOL

0 to 7	7	Sandstone, bedded..	Tertiary....	. Arikaree
7 to 22	15	Sandstone,.........	Tertiary....	. Arikaree
22 to 36	15	Sandstone,.........	Tertiary....	. Arikaree
36 to 114	78	Shales, variegated ..	Tertiary....	White Riv

SECTION ON RATTLESNAKE BUTTE

0 to 8	8	Sandstone, Miocene, to thin bedded	Tertiary	. Arikaree
8 to 8	10	Volcanic Ash.......	Tertiary	. Arikaree
18 to 58	40	Sandstone, etc.	Tertiary	White Riv
58 to 158	100	Shales, ...	Tertiary	White Riv
158 to 200	42	Shales, ...	Cretaceous..	....Pierre


MAP OF SOUTH DAKOTA
BETWEEN THE MISSOURI RIVER
AND THE BLACK HILLS
SCALE : 1" = 20 MILES
WITH CROSS SECTION
ELLWOOD C. PERISHO.
ARMSTRONG
BUTTE
SULLY
HUGHES
STANLEY
MEADE
PENNINGTON
CUSTER
FALL RIVER
BADLANDS
WASHINGTON
WASHABAUGH
PINE RIDGE
SHANNON
RESERVATION
LUGENBEEL
ROSEBUD
MEYER
TRIPP
LOWER BRULE RESERVATION
CROW CREEK RESERVATION
BUFFALO
HYDE
BRULE
GREGORY
CHARLES MIX
Missouri River
White River
Cheyenne River
Bad River
PIERRE
Chamberlain
CROSS SECTION ON LINE A-B
Scale : 1" = 30 Miles.
10 Loup Fork, or Arikaree
9 White River.
8 Ft. Pierre.
7 Niobrara.
6 Ft. Benton.
5 Dakota.
4 Triassic.
3 Paleozoic.
2 Algonquin and
1 Massive.

Preliminary Report on the Flora and Fauna of the Eastern Part of the Rosebud Reservation, Now Known as Gregory County

By Sheridan R. Jones

Vetgetable Divisions.—The Rosebud reservation may be divided into two great divisions of vegetable growth, namely the Higher or Upland district, represented by the surface of the higher prairie lands, and the Lower or Lowland district, represented in its extreme by the valleys of the two Whetstones. There is, however, another division which takes its place just below the Upper, but not in such an extreme as the Lower, namely, the valley of the Ponca, with an average elevation of about eighteen hundred and fifty feet.

A distinct line separates the Upland from the Lowland districts. It is the impervious layer underlying the sand stratum from which arise the springs. These springs are fundamentally responsible for the two vegetative divisions.

The loam of the Higher zone is as favorable for rich vegetative growth as that of the Lower zone, with but one exception—it lacks the water supply. While the rainfall is the same in both cases the sand stratum immediately underlying the surface loam forms a complete drainage and dryer for the upper stratum, at the same time transfering the water intended for the Upland, as additional irrigation for the Lowland or Lower zone.

As a result we have the vegetation of the prairie or Upland district light and composed of dry soil varieties, while the Lowland district is covered with heavy vegetation.

Buffalo and Grama Grass.—Quite an interesting feature is noticed in the presence of the buffalo and grama grass of the Rosebud. These two varieties generally classed as one and the same grass by the common run of folk are, with their old associate, the buffalo, fast becoming exterminated by the inroad of cultivation and the over-crowded condition of the range. However, they may yet be found in considerable quantities growing luxuriantly on the gently sloping prairie lands and low hill sides which have not as yet been leased for grazing. What attracted the attention of the survey was the fact that in no instance were the two varieties growing abundantly over the same area—scarcely any grama being found in the plots covered by the buffalo grass and again wherever the grama was found at its best, little or no buffalo grass was present. In either case these grasses were predominant—other species being poorly represented as to members as well as in foliage. Those patches or plots often cover only an acre of land while again they may include a series of small and gently sloping hillsides or a small flat valley comprising many acres. Areas of the above nature are not sharply delineated but gradually thin out with an increase of the more common varieties of the district which again become more scarce with the increase of the grama or buffalo grass as the case may be, occupying the next plot. Thus the reservation, where these grasses are found, presents a district spotted with plots of grama and buffalo grass, the former being no doubt the more abundant variety.

Smuts, Rusts, etc.—One of the most interesting as well as gratifying results obtained by the examination of this district was the almost total absence of any of the parasites which work detriment to crops, fruits and foliage trees, wherever present. Reports obtained from the settlers of the region as well as observations made of the standing crops all gave evidence of the scarcity of anything akin to rusts (*Accidiomycetes*) or smuts (*Hemibasideae*).

Blights were only noticed in a few instances, notably the Black Knot or Wild Plum parasite and a fungus attacking the leaves of some of the Milkweed family. These, however, were quite rare—the former being present only in one or two instances.

The gall fly, causing the gall to form on some species of the goldenrod, which many of us in childhood days, before fishing tackle was so easily obtained, have used as "bobbers" and from which it gets its common name of "Indian bobber," was prominent, although not very abundant.

Thus we may consider the reservation district as practically free from these detrimental forms of animal and plant life.

The potato and the squash or melon beetles were reported in a few cases as being more or less present tho' not in dangerous numbers; however, direct evidence of their presence was not secured. The cut worm and grub worm (larva of common June beetle) were reported as being absent, with the exception of a few instances of the latter.

History of Timber, its Disappearance.—Prior to 1868-9 when the settlers first made their way in considerable numbers into the northernNebraska region, and a few into what is now the older half of Gregory County, the low lands along the Ponca and Whetstone Creeks were covered with a heavy growth of timber. Characteristic and typical of this growth were the oak, elm, ash and cottonwood which are found in considerable numbers in the other wooded portions of the state. The growth, however, was confined to the low lands and valleys, rarely extending upward as far as one hundred feet of the surface level.

Soon the settlers along the southern border of the state made away with the timber and what was not taken was destroyed by the prairie fires which always accompany the advance guard of settlement in new regions.

Now only a few "old timers" stand out above the undergrowth which is fast springing up in place of the older timber. This recent growth is composed chiefly of the older species, from two to twelve inches in diameter. However, the oak, so prominent in the earlier history of the country, has disappeared to a great extent—only a few weakly specimens cling to the sides of the ravines and gullies feeding the creek valleys. With the disappearance of the oak has come into prominence the box elder which stands next to the ash and elm in abundance, while an undergrowth of willow, plum and chokecherry borders the creeks and their tributaries. As yet tree planting has not been followed with success throughout the Higher zone.

The following list is based on a midsummer collection of Flora and Fauna gathered in 1904:*

*In the arrangement of the list Mr. Jones was assisted by Prof. Lommen.

Pteridophyta. Ferns, Horsetails, Scouring Rushes.

Polypodiaceae. Fern Family.

Woodsia scopulina, D. C. Eaton. Rocky Mountain Woodsia.

Rare; shady crevices of sandstone composing Burnt Rock.

Equisetaceae. Horsetail Family.

Equisetum hyemale L. Common Scouring Rush.

Common; moist ravines and creek bottoms.

Equisetum palustre L. Marsh Horsetail.

Very common; moist ravines and creek bottoms.

Spermatophyta. Seed Plants.

Monocotyledones.

Typhaceae. Cat-tail Family.

Typha latifolia L. Broad-leaved Cat-tail.

Sparganiaceae. Bur-reed Family.

Sparganium androcladum (Englm.) Morong. Branching Bur-reed.

On sandy bottom of Ponca Creek.

Naiadaceae. Pond Weed Family.

Potamogeton amplifolius Tuckerm. Large-leaved Pondweed.

Throughout, especially in upland mudholes.

Potamogeton natans L. Common Floating Pondweed.

Sandy stream bed of Ponca Creek.

Alismaceae. Water-plaintain Family.

Alisma plantago-aquatica L. Water Plaintain.

Common; marshes of Ponca Creek and tributaries.

Sagittaria latifolia Willd. Broad-leaved Arrowhead.

Common throughout; mucky spring beds and standing water.

Gramineae. Grass Family.

Agropyron violaceum (Hornem) Vasey. Purplish Wheat-grass.

Common; lowlands and low prairies; in colonies.

Agrostis alba L. Red-top. Herd's Grass.

Common; dry hillsides, prairies, damp draws; associated with Stout Wild Rye.

Andropogon furcatus Muhl. Forked Beard-grass.

Common over entire region; most abundant on loamy soil.

Bouteloua curtipendula (Michx.) Torr. Racemed Bouteloua.

Common; associated with the Purple Bergamot.

Bouteloua oligostachya (Nutt.) Torr. Grama-grass. Mesquite-grass.

Common throughout; in plats associated with the Buffalo-grass.

Bulbilis dactyloides (Nutt.) Raf. Buffalo Grass.

Common on hillsides and dry prairies; associated with the Grama-grass.

Cenchrus tribuloides L. Bur-grass. Hedgehog-grass. Sand bur.

Occasional patches; along sandy trails near Ponca Creek and tributaries.

Calamovilfa longifolia Hook. (Hack.) Long-leaved Reed-grass.

Ravines and damp sandy places.

Elymus robustus Scribn. & J. G. Sm. Stout Terrell. Stout Wild Rye.

Common; along creeks in moist loamy soil; associated with slough grass and sedges.

Elymus virginicus L. Terrell-grass. Virginia Wild Rye.

Common; bottoms of Ponca Creek and tributaries.

Eragrostis secundiflora Presl. Clustered Eragrostis.

Throughout; in patches on dry prairies.

Festuca ovina L. Sheep's Fescue-grass.

Scarce: lowlands at junction of north and south branches of Whetstone Creek.

Ixophorus glaucus (L.) Nash. Yellow Fox-tail. Pigeon-grass.

Rare; waste places and cultivated fields.

Ixophorus italicus (L.) Nash. Italian Millet. Hungarian grass.

Common; roadsides; escaped from cultivation.

Koeleria cristata (L.) Pers. Koeleria.

Abundant everywhere; sandy soil.

Panicum capillare (L.) Witch-grass. Tumble-weed.

Rare; depressions and damp loam along valley of Whetstone.

Panicum pubescens Lam. Hairy Panicum.

Abundant; dry deserted fields and roadsides.

Schedonnardus paniculatus (Nutt.) Trelease. Schedonnardus.

Rare; low lands at junction of branches of Whetstone Creek.

Spartina cynosuroides (L.) Willd. Tall Marsh-grass.

Common; luxuriant; along water courses; associated with sedges.

Zizannia aquatica L. Wild Rice. Indian Rice. Water Oats.

Quite abundant along Ponca Creek.

Cyperaceae. Sedge Family.

Carex arcta Boott. Northern Clustered Sedge.

Throughout; sloughs along tributaries of the Whetstone Creek.

Carex cristatella Britton. Crested Sedge.

Common; along water courses; associated with the Tall Marsh-grass.

Carex flava L. Yellow Sedge.

Common; hillsides bordering water courses; hardy.

Carex hystricina Muhl. Porcupine Sedge.

Scarce; low valleys and swampy creek beds.

Carex lurida Wahl. Sallow Sedge.

Throughout; mucky sloughs and damp creek valleys.

Carex viridula Michx. Green Sedge.

Hillsides bordering on water courses.

Cyperus schweinitzii Torr. Schweinitz's Cyperus.

Abundant; sandy creek valleys and borders of sandy pools.

Cyperus strigosus robustior L. Straw-colored Cyperus.

Common; banks of Whetstone and marshy tributaries; sandy loam and gravelly beds.

Eleocharis wolfii A. Gray. Wolf's Spike-rush.

Meadows, depressions and marshy creek beds.

Rynchospora alba (L.) Vahl. White Beaked-rush.

Abundant in places, but not common; marshes.

Scirpus lacustris L. Great Bulrush. Mat-rush.

Quite abundant; creeks and stagnant ponds; associated with the Long-beaked Arrowhead and the Large-leaved Pondweed.

Commelinaceae. Spiderwort Family.

Tradescantia bracteata Small. Long-bracted Spiderwort.

Very rare; damp valley near Missouri River.

Tradescantia virginiana L. Spiderwort.

Not very common; hillsides, sandy soil, and dry creek beds.

Juncaceae. Rush Family.

Juncus effusus L. Common Rush. Bog Rush. Soft Rush.

Rare; swamps along the Whetstone and its tributaries.

Juncus pelocarpus E. Meyer. Brownish-fruited Rush.

Rare; marshy creek beds between St. Elmo and Burnt Rock.

Liliaceae. Lily Family.

Allium cernuum Roth. Nodding Wild Onion.

Rare; sidehills of creeks; damp to medium dry soil.

Yucca glauca Nutt. Bear-grass.

Abundant in some localities; high, dry, rocky to sandy hills.

Convallariaceae. Lily-of-the-Valley Family.

Polygonatum commutatum (R. & S.) Dietr. Smooth Solomon's Seal.

Common; shady wooded districts along Ponca Creek.

Dicotyledones.

Salicaceae. Willow Family.

Populus deltoides Marsh. Cottonwood. Necklace Poplar.

Lowlands of the Missouri and its tributaries.

Salix alba vitellina (L.) Koch. White Willow. Huntington Willow. Golden Osier.

Common; creeks and runs and along Missouri River; associated with *Salix fluviatilis.*

Salix fluviatilis Nutt. Sandbar Willow, Riverbank Willow, Red Willow.

Very common; sandy soil along the Missouri River and its tributaries.

Fagaceae. Beech Family.

Quercus macrocarpa Michx. Mossy-cup or Burr Oak.

Very common; ravines and hillsides.

Ulmaceae. Elm Family.

Ulmus americana L. American, White, or Water Elm.

Very common; along water courses; small.

Urticaceae. Nettle Family.

Urtica gracilis Ait. Slender Nettle.

Common; loamy, damp to marshy soil; along Whetstone and tributaries.

Polygonaceae. Buckwheat Family.

Polygonum bellardi All. Bellard's Knot Weed.

Common throughout; along trails.

Polygonum convolvulus L. Black Bindweed.

Not general; damp ravines and cuts.

Polygonum punctatum Ell. Dotted or Water Smartweed.

Common throughout; well watered soil.

Chenopodiaceae. Goosefoot Family.

Chenopodium leptophyllum (Moq.) Nutt. Narrow-leaved Goosefoot.

Common throughout. Dry sandy and clay soil.

Cycloloma atriplicifolium (Spreng.) Coult. Cycloloma.

Quite common; damp soil along water courses.

Salsola tragus L. Russian Thistle.

Common; roadsides, fields and waste plains.

Amaranthaceae. Amaranth Family.

Amaranthus hybridus L. Slender Pigweed.

Along lowlands of Whetstone region.

Amaranthus retroflexus L. Rough Pigweed.

Lowlands in loam or clay.

Nyctaginaceae. Four-o'clock Family.

Allionia nyctaginea Michx. Heart-leaved Umbrellawort.

Portulacaceae. Purslane Family.

Talinum parviflorum Nutt. Small-flowered Talinum.

Sandy hillsides; evening and night bloomer; associated with Yellow Flax.

Ranunculaceae. Crowfoot Family.

Clematis virginiana L. Virginiana. Virgin's Bower.

Common; moist woody places.

Ranunculus acris L. Tall or Meadow Buttercup.

Rare; ravines along water courses.

Thalictrum polygamum Muhl. Tall Meadow-rue.

Moist, open, sunny regions.

Cruciferae. Mustard Family.

Bursa bursa-pastoris (L.) Britton. Shepherd's Purse.

Very common; along trails and in thinly wooded districts.

Erysium cheiranthoides L. Worm-seed or Treacle Mustard.
Scarce; very shady damp soil; along Ponca Creek and tributaries.

Roripa palustris (L.) Bess. Marsh or Yellow Watercress.
Rare; damp beds of partially dried creeks in Ponca region.

Capparidaceae. Caper Family.

Cleome serrulata Pursh. Pink Cleome.
Quite common; along creeks, and in water places; associated with Ironweeds.

Polanisia graveolens Raf. Clammy Weed.
Quite common; sandy, gravelly hillsides and valleys; associated with *Lotus americanus.*

Grossulariaceae. Gooseberry Family.

Ribes hudsonianum Richards. Northern Black Currant.
Not common; damp wooded districts along the Ponca Creek.

Ribes aureum Pursh. Golden, Buffalo, or Missouri Currant.
Common along the Whetstone; damp loam in woody districts.

Ribes uva-crispa L. Garden Gooseberry.
Escaped from cultivation; along the Whetstone and its tributaries.

Rosaceae. Rose Family.

Potentilla arguta Pursh. Tall or Glandular Cinquefoil.
Common; on loamy soil in damp shady places; associated with ferns and sedges.

Rosa arkansana Porter. Arkansas Rose.
Very common; all over the Rosebud region.

Pomaceae. Apple Family.

Sorbus americana Marsh. American Mountain Ash, Dogberry.
Very common; damp soil in gullies and ravines.

Drupaceae. Plum Family.

Prunus americana Marsh. American Wild Yellow or Red Plum.
Common; lowlands along the Missouri River and Creeks of Rosebud.

Prunus pumila L. Sand Cherry. Dwarf Cherry.
Common throughout; sandy hillsides; poor growth.

Prunus virginiana L. Choke Cherry.

Common; along water courses and lowlands near the Missouri.

Mimosaceae. Mimosa Family.

Acuan illinoensis (Michx.) Kuntze. Illinois Mimosa.

Prairies, hills along streams; loamy soil; hardy.

Morongia uncinata (Willd.) Britton. Sensitive Brier.

Throughout but scarce; hillsides to shady lower places.

Papilionaceae. Pea Family.

Amorpha fruticosa L. False or Bastard Indigo.

Very common; prairies and hillsides, associated with cone flowers.

Amorpha nana Nutt. Fragrant False Indigo.

Quite common; sandy loam; low valleys and hillsides.

Astragalus aboriginorum Richards. Indian Milk Vetch.

Quite common; dry soil along roads and hillsides; Whetstone regions.

Astragalus carolinus L. Carolina Milk Vetch.

Rare; moist sandy places along water courses; very rank growth.

Falcata comosa (L.) Kuntze. Wild or Hog Peanut.

Quite common; low wooded districts.

Glycyrrhiza lepidota Pursh. Wild Licorice.

Common; medium dry loam on low hillsides.

Kuhnistera oligophylla (Torr.) Heller. Slender White Prairie Clover.

Quite rare; prairies and sandy hillsides.

Kuhnistera purpurea (Vent.) Mac M. Violet Prairie Clover.

Very common; prairies and hillsides; associated with False Indigo.

Lotus americanus (Nutt.) Bisch. Prairie Bird's Foot Trefoil.

Quite common; sandy loam of rolling prairie.

Parosela aurea (Nutt.) Britton. Golden Parosela.

Quite rare; loam and sandy hillsides. Whetstone region.

Parosela enneandra (Nutt.) Britton. Slender Parosela.

Common; hillsides along creeks, rarely on prairies; loam and clay.

Psoralea argophylla Pursh. Silver-leaf Psoralea.

Common; prairies and upper hillsides.

Psoralea collina Rydberg. *Nebraska Psoralea.* Quite rare; dry plains and hillsides.

Psoralea cuspidata Pursh. Large-bracted Psoralea.

Common; especially on sandy loam of hillsides and valleys; Whetstone region.

Psoralea digitata Nutt. Digitate Psoralea.

Rare; on prairies.

Psoralea esculenta Pursh. Pomme Blanche. Prairie Apple or Turnip.

Quite rare; sandy hillside throughout.

Psoralea onobrychis Nutt. Sainfoin Psoralea.

Scarce; shady moist places along water courses.

Spiesia lamberti (Pursh.) Kuntze. Stemless Loco Weed or Crazy Weed.

Throughout, not abundant; sandy prairies; associated with Psoralea.

Oxalidaceae. Wood Sorrel Family.

Oxalis stricta L. Upright Yellow Wood-sorrel.

Common; loamy soil; damp shady places in valleys.

Linaceae. Flax Family.

Linum rigidum Pursh. Large-flowered Yellow Flax.

Quite common; sandy sides and tops of hills; in colonies.

Linum sulcatum Riddell. Grooved Yellow Flax.

Quite common; dry sandy prairies and hillsides.

Polygalaceae. Milkwort Family.

Polygala alba Nutt. White Milkwort.

Loam and clay soils of side hills near Wheeler; associated with buffalo grass.

Polygala verticillata L. Whorled Milkwort.

Scarce; loam and sandy loam; solitary.

Euphorbiaceae. Spurge Family.

Euphorbia marginata Pursh. White-margined Spurge.

Not common; mostly along the Missouri; hillsides, roadsides and dry valleys.

Euphorbia nuttallii (Engelm.) Small. Prairie Spurge.

Not common; low moist hillsides and ravines; rarely on prairies.

Celastraceae. Staff-tree Family.

Euonymus atropurpureus Jacq. Burning Bush. Wahoo.

Rare; moist places along creeks; Whetstone region.

Tiliaceae. Linden Family.

Tilia americana L. Basswood. American Linden. Whitewood.

Rare; small trees, associated with the Burr Oak.

Violaceae. Violet Family.

Viola obliqua Hill. Meadow or Hooded Blue Violet.

Common throughout; moist shady places.

Cactaceae. Cactus Family.

Cactus missouriensis (Sweet.) Kuntze. Missouri or Nipple Cactus.

Rare; sandy hills.

Opuntia tortispina Engelm. Twisted-spined Cactus.

Very common; sandy hillsides.

Elaeagnaceae. Oleaster Family.

Lepargyraea argentea (Nutt.) Greene. Buffalo Berry. Rabbit Berry.

Common; water courses and lowlands near the Missouri; of scanty growth.

Lythraceae. Loosestrife Family.

Lythrum alatum Pursh. Wing-angled Loosestrife.

Quite common; moist creek bottom; associated with grasses and sedges.

Onagraceae. Evening Primrose Family.

Gaura parviflora Dougl. Small-flowered Gaura.

Common throughout; dry loam.

Onagra biennis (L.) Scop. Common Evening Primrose. Night Willow-herb.

Very common; hillsides and sandy to loamy prairies; associated with cone flowers.

Oenothera rhombipetala Nutt. Rhombic Evening Primrose.

Quite common; sandy hillsides and ravines; from solitary flowers to colonies.

Umbelliferae. Carrot Family.

Sium cicutaefolium Gmel. Hemlock Water Parsnip.
Common; along water courses; sometimes in colonies.

Cornaceae. Dogwood Family.

Cornus baileyi Coult. & Evans. Bailey's Cornel or Dogwood.

Primulaceae. Primrose Family.

Steironema ciliatum (L.) Raf. Fringed Loosestrife.
Common; valley of Ponca Creek and tributaries; associated with mints.

Oleaceae. Olive Family.

Fraxinus lanceolata Borck. Green Ash.
Common; loam and sandy soil; along creeks and in lowlands; hardy.

Apocynaceae. Dogbane Family.

Apocynum hypericifolium Ait. Clasping-leaved Dogbane.
Quite common; damp loamy soil in ravines and water courses.

Asclepiadaceae. Milkweed Family.

Acerates angustifolia (Nutt.) Dec. Narrow-leaved Milkweed.
Rare; sand and sandy loam; leaves affected by rust.
Acerates viridiflora (Raf.) Eaton. Green Milkweed.
Common; especially in waste places of cultivated region.
Asclepias incarnata L. Swamp Milkweed.
Common; moist ravines; of rank growth.
Asclepias pumila (A. Gray.) Vail. Low Milkweed.
Common; dry plains and hills; along the Missouri.
Asclepias ovalifolia Dec. Oval-leaved Milkwort.
Common; damp sandy valleys and hillsides; leaves rusted.
Asclepias syriaca L. Common Milkweed. Silkweed.
Common throughout; low valleys and other damp places.
Asclepias sullivantii Engelm. Sullivan's Milkweed.
Sandy loam and moist soil along the river near Wheeler.

Convolvulacae. Morning Glory Family.

Convolvulus sepium L. Hedge or Great Bindweed. Rutland Beauty.
Common throughout; growing best in damp thickets and ravines.

Ipomoea leptophylla Torr. Bush Morning Glory.
Rare; damp ravines; rank growth.

Boraginaceae. Borage Family.

Onosmodium molle Michx. Soft-hairy False Gromwell.
Common; loamy prairies, luxuriant.

Verbenaceae. Vervain Family.

Verbena canadensis (L.) Britton. Large-flowered Verbena.
Very common; dry loam along roadsides.

Verbena hastata L. Blue Vervain. Wild Hyssop.
Common throughout; damp low places, around ponds.

Verbena stricta Vent. Hoary or Mullen-leaved Vervain.
Common; dry, loamy valleys.

Verbena urticifolia L. White or Nettle-leaved Vervain.
Common; waste places and along creeks; Whetstone region.

Labiatae. Mint Family.

Lycopus americanus Muhl. Cut-leaved Water Hoarhound.
Rare; very damp and shady places; along the Ponca and tributaries.

Salvia lanceolata Willd. Lance-shaped Sage.
Loam and clay; low plains and roadsides.

Stachys tenuifolia Willd. Smooth Hedge-nettle.
Common; loam along draws and creeks; Whetstone and tributaries.

Solanaceae. Potato Family.

Physalis philadelphica Lam. Philadelphia Ground Cherry.
Rare; quite damp loam; valley of the Whetstone.

Scrophulariaceae. Figwort Family.

Pentstemon grandiflorus Nutt. Large-flowered Beard-tongue.
Quite common; loamy soil on prairies and hillsides along the Missouri.

Veronica americana Schwein. American Brooklime.
Very common; in stream bed of the Ponca and tributaries.

Orobanchaceae. Broom-rape Family.

Orobanche ludoviciana Nutt. Louisiana Broom-rape.
Abundant on sandy hillsides west of Burnt Rock.

Plantaginaceae. Plaintain Family.

Plantago purshii R. & S. Pursh's Plaintain.

Quite common; patches on loamy prairie; associated with Grama and Buffalo Grass.

Caprifoliaceae. Honeysuckle Family.

Symphoricarpos racemosus Michx. Snowberry.

Quite common, loamy damp hillsides; in patches.

Cichoriaceae. Chicory Family.

Lactuca pulchella (Pursh.) D. C. Large-flowered Blue-lettuce.

Throughout the region; sunny places of lowlands.

Lactuca scariola L. Prickly Lettuce.

Common throughout; abandoned fields and waste places.

Lactuca spicata (Lam.) Hitche. Tall Blue Lettuce.

Common; moist valleys; Whetstone district.

Sonchus arvensis L. Corn Sow-thistle. Milk-thistle.

Very common; clay and loam bottoms.

Ambrosiaceae. Ragweed Family.

Ambrosia artemisiaefolia L. Ragweed. Hogweed. Wild Tansy.

Common throughout; dry soil everywhere.

Ambrosia psilostachya D. C. Western Ragweed.

Common; along the Whetstone and tributaries.

Ambrosia trifida L. Horse-cane. Bitterweed. Great Ragweed.

Common throughout; in lowland region.

Compositae. Thistle Family.

Artemisia cana Pursh. Hoary Sagebrush.

Very common; dry prairies, deserted fields and hillsides.

Artemisia frigida Willd. Pasture Sagebrush. Wormwood Sage.

Common; dry, sandy and rocky hills and hillsides.

Aster incanopilosus (Lindl.) Sheldon. White Prairie Aster.

Common; dry sandy loam and clay; roadsides of Whetstone region.

Aster oblongifolius Nutt. Aromatic Aster.

Common; dry, sandy loam and clay; roadsides of Whetstone region.

Bidens frondosa L. Beggar Ticks. Sticktight.

Common; damp, shady places; Whetstone and tributaries.

Boltonia diffusa Ell. Panicled Boltonia.
Common throughout; damp, sandy loam.
Brauneria pallida (Nutt.) Britton. Pale Purple Cone-flower.
Sandy, loamy hillsides and prairies; associated with Yellow Cone-flowers.
Carduus altissimus L. Tall or Roadside Thistle.
Along roadsides and in bottom lands near creeks.
Carduus lanceolatus L. Common Bur or Spear Thistle.
Old fields and waste places along roadsides.
Chrysopsis hispida (Hook.). Nutt. Hispid Golden Aster.
Very common; dry prairies, hillsides and valleys, and along the Ponca.
Engelmannia pinnatifida T. & G. Engelmannia.
Rare; along hillsides of the Missouri.
Eriocarpum spindulosum (Nutt.) Greene. Cut-leaved Eriocarpum.
Very common; sandy loam; rolling prairies and hillsides.
Helianthus annuus L. Common Sunflower.
Common; prairies, roadsides and valleys.
Helianthus tuberosus L. Jerusalem Artichoke. Earth Apple.
Very abundant along creek bottoms.
Heliopsis helianthoides (L.) B. S. P. Ox-eye. False Sunflower.
Hymenopappus corymbosus T. & G. Cormybed or Smooth White Hymenopappus.
Rare; sandy prairies and hillsides.
Lacinaria acidota (Engelm. & Gray.) Kuntze. Slender Button Snakeroot.
Quite common; sandy and dry loamy prairies.
Ratibida columnaris (Sims.) D. Don. Long-headed or Prairie Cone-flower.
Common throughout; sandy and sandy loam soil; hillsides and high valleys.
Ratibida tagetes (James). Barnhart. Short-rayed Cone-flower.
Dry plains and sandy hillsides.
Rudbeckia triloba L. Thin-leaved Cone-flower.
Rare; sandy and dry loam.

Solidago mollis Bartl. Velvety Goldenrod.
Common; dry prairies and hillsides.
Solidago nemoralis Ait. Gray or Field Goldenrod. Dyer's Weed.
Throughout; dry loamy soil, in colonies or patches.
Solidago serotina Ait. Late Goldenrod.
Quite rare; moist lowlands and along creeks; associated with wild hyssop.
Thelesperma trifidum (Poir.) Britton. Fine-leaved Thelesperma.
Quite common; associated with Prairie Cone-flower.
Vernonia baldwinii Torr. Baldwin's Ironweed.
Found in moist soil along creeks and not on dry soil.

Birds.

Limocolae. Shore Birds.

Scalopacidae. Snipes, Sandpipers.
Bartramia longicauda (Bechstein.) Bartramian Sandpiper.
On the prairies.

Gallinae. Gallinaceous Birds, Fowls.

Tetraonidae. Grouse, Partridges, etc.
Colinus virginianus (L.) Bob White. Quail.
Very common in low ravines.
Tympanuchus americanus (Reichenbach.) Prairie hen or chicken. Common Pinnated Grouse.
Very common on lowlands.

Raptores. Birds of Prey.

Cathartidae. American Vultures.
Cathartes aura (L.) Turkey Vulture.
Falconidae. Falcons, Hawks, Eagles.
Buteo borealis (Gmelin) Red-tailed Hawk.
Quite common.
Buteo lineatus (Gmelin.) Red-shouldered Hawk.
Common, but does not appear to be nesting.
Circus hudsonius (L.) Marsh Hawk.
Very scarce.
Falco sparverius L. American Sparrow Hawk.
Scarce; noticed in timber region.

Bubonidae. Horned Owls, etc.

Asio acipitrinus (Pallas.) Short-eared Owl.

Common; along creek valleys; nesting.

Speotyto cunicularia hypogaea (Bonaparte.) Burrowing Owl.

Very scarce.

Coccyges. Cuckoos, Etc.

Cuculidae. Cuckoos.

Coccygus americanus (L.) Yellow-billed Cuckoo.

Quite common; Ponca and Whetstone districts.

Alcedinidae. Kingfishers.

Ceryle alcyon (L.) Belted Kingfisher.

Common; running streams.

Pici. Woodpeckers, Wrynecks, Etc.

Picidae. Woodpeckers.

Colaptes auratus (L.) Flicker.

Very common; wooded districts.

Dryobates pubescens (L.) Downy Woodpecker.

Common; wooded districts.

Dryobates villosus (L.) Hairy Woodpecker.

Common; wooded districts.

Melanerpes erythrocephalus (L.) Red-headed Woodpecker.

Common; dense woods.

Macrochires. Goatsuckers, Swifts, Humming Birds, Etc.

Caprimulgidae. Goatsuckers, etc.

Chordeiles virginianus (Gmelin.) Night Hawk.

Very common.

Passeres. Perching Birds.

Tyrannidae. Tyrant Fly Catchers.

Empidonax minimus Baird. Least Fly Catcher.

Very common; small bushes along woody creeks.

Alaudidae. Larks.

Otocoris alpestris praticola Henshaw. Prairie Horned Lark.

Very common.

Corvidae. Crows, Jays, Magpies.

Corvus americanus Audubon. American Crow.

Common; does not nest.

Cyanocitta cristata (L.) Blue Jay.

Scarce; Burnt Rock Creek.

Icteridae. Blackbirds, Orioles, etc.

Agelaius phoeniceus (L.) Red-winged Blackbird.

Quite common.

Icterus galbula (L.) Baltimore Oriole.

Common; wooded districts.

Icterus spurius (L.) Orchard Oriole.

Scarce; old and young noted.

Molothrus ater (Boddaert). Cow Bird.

Common.

Sturnella magna (L.). Meadow Lark.

Most common bird of the region.

Sturnella magna neglecta (Audubon). Western Meadow Lark.

Very scarce, fields.

Fringillidae. Finches, Sparrows, etc.

Ammodramus bairdii. Baird's Sparrow.

Very common; all over the region.

Ammodramus savannarum passerinus Wilson. Grasshopper Sparrow.

Quite common.

Calamospiza melanocorys Stejneger. Lark Bunting.

Fairly common.

Chondestes grammacus (Say). Lark Sparrow.

Scarce; slightly wooded creek valleys.

Melospiza fasciata (Gmelin). Song Sparrow.

Common; wooded regions.

Pipilio erythrophthalamus (L.) Towhee.

Common; low woods.

Passer domesticus (L.) English Sparrow.

Common.

Spinus tristis (L.) American Goldfinch.

Common; wooded districts.

Spiza americana (Gmelin). Dickcissel.

Scarce; fields and shrubs.

Spizella monticola (Gmelin.) Tree Sparrow.

Very common; low districts.

Spizella socialis (Wilson). Chipping Sparrow.

Common; slightly timbered creek valleys.

Hirundinidae. Swallows.

Hirundo erythrogaster Boddaert. Barn Swallow.

Scarce; around old buildings and huts.

Laniidae. Shrikes.

Lanius ludovicianus L. Loggerhead Shrike.

Scarce; timber regions.

Vireonidae. Vireos.

Vireo belli Audubon. Bell's Vireo.

Scarce; only one specimen noted.

Mniotiltidae. Wood Warblers.

Dendroica aestiva (Gmelin) Yellow Warbler.

Common; along bushy creek beds.

Troglodytidae. Wrens, Thrashers. etc.

Galeoscoptes carolinensis (L.) Catbird.

Common; along creeks with underbrush.

Harporhynchus rufus (L.) Brown Thrashers.

Common; low woods.

Troglodytes aedon (Vieillot) House Wren.

Not common; houseyards along the Ponca.

Certhiidae. Creepers.

Certhia familiaris americana L. Brown Creeper.

Scarce; Ponca Creek.

Paridae. Nuthatches and Tits.

Parus atricapillus (L.) Chickadee.

Common; wooded water courses.

Turdidae. Thrushes, Stonechats, Bluebirds, etc.

Sialia sialis (L.) Blue Bird.

Fairly common; settled districts.

Hylocichla mustelina (Gmelin) Wood Thrush.

Scarce; Ponca district.

Notes on the Flora and Fauna of the Rosebud Reservation, West of Gregory County.

By Albert B. Reagan

NOTE—The following article on the fauna and flora of the Rosebud Reservation, by Mr. Albert B. Reagan of Washington, is printed in this bulletin as written by the author, without any changes, except that Prof. Lommen has put in brackets the later names for a number of the plants discussed. The Survey gladly publishes a second article on the fauna and flora of the Rosebud, for the reason, that the observations determining the data for the following articles, were made, not only at different times, but at different places on the Reservation. Mr. Reagan's article being based on work done in the western part of the Reservation, while that of Mr. Jones was confined largely, to the eastern part.

State Geologist.

Plants.

The following list of identified plants are the result of the author's observations during the spring, summer and fall of 1904. The work was carried on as time would permit, and, consequently, contains only a small part of the plants of the region.

The books used in identifying the plants were Wood's "Eastern Botany," Bessey's "Botany for High Schools and Colleges," Gray's "Lessons and Manual of Botany," and Coulter's "Manual of Rocky Mountain Botany."

Ranunculaceae:

1. *Anemone caroliniana* Walt.
   Numerous.
2. *Delphinium azureum* Michx. Lark-spur.
   Common.
3. *Caltha palustris* L. Marsh Marigold.
   Common in low places.

Cruciferae:

4. *Brassica arvensis* (L.) Mustard.
   Only one plant was seen on the Butte creek wagon road one mile east of the Widow Dire's place (specimen not native).

5. *Lepidum apetalum* Willd. Peppergrass.
   Dry places, yards, road sides, etc.

6. *Camelinia sativa* (L.) Crantz. False Flax.
   Common.

Violaceae:

7. *Viola cuculata* Gray. [*Viola oliqua* Hill. Meadow or Hooded Blue Violet.]
   Common in valleys.

8. *Viola sagittata Ait.* Arrow-leaved Violet.
   Common in damp places (April 6).

9. *Viola delphinifolia* Don. Prairie Violet. [*Viola pedatifida.*]

10. *Viola rotundifolia* Michx. Yellow Violet.

Portulacaceae:

11. *Portulaca retusa* Engelm. Purslane.
    Grows very profusely on dams and cultivated grounds.

12. *Portulaca pilosa* L. Hairy Portulaca.
    Common, but not so profuse as the species above.

Malvaceae:

13. *Malvastrum coccineum* (Pursh.) Gray. Red False Mallow.

Linaceae:

14. *Linum sulcatum* Riddell. Grooved Yellow Flax.
    Dry soil; common (June 1).

Oxalidaceae:

15. *Oxalis corniculata* L. Yellow Wood Sorrel. [*Oxalis stricta* L.]

Vitaceae:

16. *Vitis aestivalis* Michx. (Same grape, Var. bicolor LeConte.)

Aceraceae:

17. *Negundo aceroides.* Moench. Box Elder. [*Acer negundo* L.].
Common along streams.

Anacardiaceae:

18. *Rhus glabra* L. Scarlet Sumach.
19. *Rhus copallina* L. Dwarf Sumach.
20. *Rhus toxicodendron* L. Poison Ivy. [*Rhus radicans L.*]
21. *Rhus trilobata* Nutt. (R. *canadensis,* var. *trilobata,* Gray.) Ill-scented Sumach.
The four *Rhus* species above are very common. The poison ivy is found in the valleys, even away from the timber.

Leguminosae:

22. *Baptisia leucophaea* Nutt. [*Baptisia bracteata* Ell.] False Indigo. Large-bracted Wild Indigo.
23. *Tephrosia virginiana* Pers. [*Cracca virginiana* L.] Goats Rue.
24. *Tephrosia.*
25. *Astragalus caryocarpus* Ker. [*Astragalus crassicarpus* Nutt.] Ground Plum. (May—June.)
26. *Astragalus plattensis* Nutt. Platte Milk Vetch. (May 14.)
Astragalus flexuosus (Hook.) Dougl. Flexile Milk Vetch.
27. *Astragalus missouriensis* Nutt. Missouri Milk Vetch.
28. *Astragalus cooperi* Gray. [Phaca neglecta T. & G. Cooper's Milk Vetch.] (May 30.)
29. *Astragalus adsurgens* Pall. Ascending Milk Vetch.
A common forage plant.

Astragalus bisculcatus (Hook.) Gray. Two-grooved Milk Vetch.

Common.

Astragalus hypoglottis L. Purple Milk Vetch or Cock's head.

Common dry prairies.

30. *Astragalus villosus*, Mx. (May-June.)
31. *Orobus atropurpureus?* (May 14.)
32. *Psoralea tenuiflora* Pursh. Few-flowered Psoralea.
33. *Psoralea argophylla,* Pursh. Silver-leaf Psoralea.
34. *Psoralea esculenta* Pursh. Prairie Apple or Turnip.
35. *Desmanthus brachylobus* Benth. [*Acuan Illinoensis* (Michx.)] Illinois Mimosa.

    Found principally in semi-wet places.
36. *Schrankia uncinata* Willd. [*Morongia uncinata* (Willd.] Britton. Sensitive Brier.

    Very common on middle uplands.

Rosaceae:

37. *Prunus,* like *P. Chicasa.*

    Numerous in thickets along streams (May 5).
38. *Prunus rosebudii.* Rosebud Dwarf Plum. (New species).

    Plant erect or decumbent growing singly or in bunches from a common root stalk, 6 in. to 1 foot in height; leaves obovate—lanceolate; flowers 2 to 4 together; fruit ovoid, nearly black when ripe, sour and astringent in taste; stone large. Rocks and sandy banks.
39. *Prunus virginiana L.* Choke Cherry.

    Banks; numerous.
40. *Rosa humilis* Marsh. Wild Rose.

    Everywhere; species very variable, flowers ranging in color from white to scarlet (June 18).
41. *Rosa woodsii* Lindl. Wood's Rose.
42. *Rosa arkansana* Porter.
43. *Rosa rubiginosa* L. Sweet brier.

    The last three species are also found on the reservation, the latter probably escaped from cultivation.

44. *Crataegus coccinea* var. *macracantha* Dudley. [*Crataegus macracantha* Lodd.] Long-spined Hawthorn.
Only one specimen of this species was seen at the head of Horse creek about eight miles southwest of the White Thunder Day School.

45. *Ribes oxyacanthoides* L. Hawthorn or Northern Gooseberry.
Not common.

46. *Ribes floridum* L'Her. Wild Black Currant.
Common on banks of streams (April 26).

47. *Ribes aureum* Pursh. Buffalo or Missouri Currant.
Common (April 20).

Onagraceae:

48. *Oenothera biennis* L. [*Onagra biennis* L.] Common Evening Primrose.

49. *Oenothera pinnatifida* Nutt. [*Anogra albicaulis* (*Pursh*), Britton.] Prairie Evening Primrose.

50. *Oenothera albicaulis* Nutt. [*Anogra pallida* (Lindl.) Britton.] White Stemmed Evening Primrose.

51. *Oenothera coronopifolia* Torr. and Gray. [*Anogra coronopifolia* Britton.] Cut-leaved Evening Primrose.

52. *Oenothera parviflora Watson.* [*Lavauxia triloba* (Nutt.) Spach.] Three-lobed Primrose.
These evening primroses are the most common flowers in the late summer and fall, the flowers of the *Compositae* family excepted.

53. *Gaura coccinea* Pursh. Scarlet Gaura.

54. *Mentzelia nuda* (Pursh.) Torr. and Gray. Bractless Mentzelia.

55. *Mentzelia ornata* Torr. and Gray. [*Mentzelia decapetala* (Pursh.) Urban & Gilg.] Showy Mentzelia.

56. *Cicyos angulatus* L. Banks and damp wooded ground.

Cactaceae:

57. *Mamillaria vivipara* Haw. [*Cactus viviparus* Nutt.] Purple Cactus.

58. *Mamillaria missouriensis* Sweet. [*Cactus missouriensis* (Sweet.) Kuntze.] Nipple Cactus.

59. *Opuntia rafinesquii Engelm.* [*Opuntia humifusa* Raf.] Western Prickly Pear.
These three species of cactus are found on the dry prairies and the broken country.

Umbelliferae:

60. *Polytaenia nuttallii* Dc.
Everywhere in early spring (April 1).
61. *Peucedanum foeniculaceum* Nutt. Fennel-leaved Parsley.
62. *Peucedanum villosum* Nutt. Hairy Parsley. (April 1.)

Compositae:

63. *Erigeron annuus* (L.) *Pers.* Daisy Fleabane, Sweet Scabious.
64. *Ambrosia artemisiaefolia* L. Hog weed.
65. *Xanthium strumarium* L. Cockleburr. Bur-weed.
Too common.
66. *Chrysanthemum leucanthemum* L. White Weed. Oxeye Daisy.
A pernicious weed everywhere.
67. *Krigia virginica,* Willd. [*Adopogon carolinianum* (Water) Britton.] Dwarf Dandelion.
Very common, usually flourishing best in the middle uplands.
68. *Helianthus annuus* L. Common Sunflower.
69. *Helianthus orgyalis* Dc. Linear-leaved Sunflower.
70. *Helianthus grosse-serratus* Martens. Saw-tooth Sunflower.
71. *Helianthus maximiliani* Schrader. Maximilian's Sunflower.
72. *Helianthus tuberosus subcanescens* Gray. Jerusalem Artichoke. Earth Apple.
73. *Solidago nemoralis* var. *incana* Gray. [*Solidago mollis* Bartl.] Velvety Goldenrod.
74. *Cnicus lanceolatus* Willd. [*Carduus lanceolatus* L.] Common Thistle.
Common on broken ground.
75. *Bidens bipinnata* L. Spanish Needle.
Few and scattering.

Lobeliaceae:

76. *Lobelia inflata* L. Indian Tobacco.
Common, used as Indian Medicine.

Oleaceae:

77. *Fraxinus americana* L. White Ash.
Moist woods.

78. *Fraxinus pubescens* Lam. [*Fraxinus pennsylvanica* Marsh.] Red Ash.
Common along streams.

79. *Fraxinus viridis* Michx. [*Fraxinus lanceolata Borck.*] Green Ash. Rarely seen.

Asclepiadaceae:

80. *Asclepias cornuti* Descaisne. [*Asclepias syriaca* L.] Common Milk Weed.

81. *Asclepias verticillata* L. var. pumila Gray [Asclepias *pumila Gray.*] Low Milk Weed.

Borraginaceae:

82. *Echinospermum floribundum* Lehm. [*Lappula floribunda* (Lehm.) Green.] Large-flowered Stickseed.

83. *Echinospermum lappula* Lehm. [*Lappula lappula* (L.) Karst] Burseed. European stickseed.

84. *Echinospermum redowskii* (Hornem.) Greene, var. *occidentalis* (Watson) Rydberg. Western Stickseed.
The three lice-weed species are very common in the wooded districts.

85. *Lithospermum hirtum.* Lehm. [*Lithospermum gmelini.*] Hairy Puccoon.
Common.

86. *Lithospermum angustifolium* Michx. Narrow-leaved Puccoon.
Common.

Convolvulaceae:

87. *Ipomoea purpurea* (L.) Roth. Common Morning Glory.
Escaped from cultivation (May 20).

88. *Ipomoea leptophylla* Torr. Wild Morning Glory.
Common along water courses.

Solanaceae:

89. *Solanum rostratum* Dunal. Beaked Nightshade. Texas Thistle.
A common weed.

Verbenaceae:

90. *Verbena hastata* L. Blue Vervain.
91. *Verbena bracteosa* Michx. Large-bracted Vervain.

Labiatae:

92. *Isanthus coeruleus* Michx. [*Isanthus brachiatus* (L.)] False Pennyroyal.
Common.
93. *Mentha canadensis* L. Wild Mint.
Common.
94. *Hedeoma hispida* Pursh. Rough Pennyroyal.
High sandy points.
95. *Salvia lanceolata* Willd. Lance-leaved Sage.
Very common.
96. *Monarda punctata* L. Horsemint.
Very common in the valleys.
97. *Teucrium occidentale* Gray. Hairy Germander.
98. *Nepeta cataria* L. Catnip. Catmint.
Not common.

Plantaginaceae:

99. *Plantago major* L. Common Plaintain.

Amaranthaceae:

100. *Amaranthus albus* L. [*Amaranthus graecizans* L.] Tumble Weed.
Very common.

Chenopodiaceae:

101. *Chenopodium album* L. Pig Weed. Lamb's Quarters.
Cultivated grounds, everywhere.

Polygonaceae:

102. *Rumex acetosella L.* Sheep Sorrel.
103. *Rumex venosus* Pursh. Veined Dock.
Occasionally seen.
104. *Rumex altissimus* Wood. Tall or Peach-leaved Dock.
105. *Rumex crispus* L. Yellow or Curled Dock.

106. *Rumex verticillatus* L. Water or Swamp Dock.
Only one plant of this species was seen.

Elaeagnaceae:

107. *Shepherdia canadensis* Nutt. [*Lepargyraea canadensis* (L.) Greene.] Canadian or Yellow Buffalo Berry.
This species and the next are to be found in nearly all of the creek valleys of the reservation. The fruit is used much by the Indians. The whites also use it for making jelly, which they highly prize.

108. *Shepherdia argentea* Nutt. [*Lepargyraea argentea* (Nutt.) Greene] Scarlet Buffalo Berry.

Urticaceae:

109. *Ulmus fulva* Michx. Red Elm.
Common along streams. It grows to be a large tree.

110. *Ulmus americana* L. White Elm.
Not common.

111. *Celtis occidentalis* L. Hackberry.

112. *Cannabis sativa* L. Hemp.
Grows in barnyards and cultivated bottom lands.

113. *Humulus lupulus* L. Hop.
Common along streams.

Fagaceae:

114. *Quercus obtusiloba* Wood. [*Quercus minor* (Marsh.) Sarg.] Post or Iron Oak.
Common.

115. *Quercus macrocarpa* Michx. Burr Oak.
Banks. This species furnishes over half of the wood of the region.

116. *Quercus macrocarpa* var. *depressa* Engelm.
A dwarf species, found in the deep dry ravines out from the main streams. It ranges in height from two feet to four feet?

Salicaceae:

117. *Salix amygdaloides* Anders. Peach-leaved Willow.

118. *Salix rostrata* Richardson. [*Salix Bebbiana* Sarg. Bebb's Willow.]
Found on banks and at the water's edge along streams.

119. *Salix longifolia* Muhl. [*Salix fluviatilis* Nutt.] Sand-bar Willow.
This willow is found principally on white river flat. A bunch was found at the Ring Thunder Day School.

120. *Populus monilifera* Ait. [*Populus deltoides* Marsh.] Cottonwood.
Borders of streams.

121. *Populus heterophylla* L. Swamp or Downy Poplar.
Borders of streams.

Pinaceae:

122. *Pinus banksiana* Lambert. [*Pinus divericata* (Ait.) Sudw.] Northern Scrub Pine.
This tree is occasionally met with on the high points of the reservation.

123. *Pinus ponderosa* Dougl. Western Yellow Pine.
This tree is found on the high points and along the breaks of the Loup Fork (Arikaree) formation.

124. *Juniperus virginiana* L. Red Cedar.
Robinson bad lands and on all the other Miocene clay bad lands of the reservation. It ranges from a shrub to a tree 20 to 40 feet in height.

Iridaceae:

125. *Sisyrinchium angustifolium* Mill. Pointed Blue-Eyed Grass.
Common (May and June).

126. *Sisyrinchium anceps* Wats. [*Sisyrinchium graminoides* Bicknell.] Stout Blue-eyed Grass.
Common.

Liliaceae:

127. *Nothoscordum striatum* Kunth. [*Nothoscordum bivalve* (L.) Britton.] False Garlic.
Very common everywhere.

128. *Yucca angustifolia* Pursh. [*Yucca glauca* Nutt.] Bear-Grass.
Very common, especially on the Miocene formation.

129. *Polygonatum giganteum* Dietrich. [*Polgonatum commutatum* R. & S. Dietr.] Great Solomon's Seal.
Common on low ground near the streams.

130. *Smilacina stellata* Desf. [*Vagnera stellata* (L.) Morong.] False Solomon's Seal.
Common in low wet places (May 1).

Commelinaceae:

131. *Tradescantia virginiana* L. Spiderwort.

Juncaceac:

132. *Juncus effusus* L. Common Rush.

Typhaceae:

133. *Typha latifolia* L. Broad-leaved Cat-tail.

Gramineae:

134. *Bromus kalmii* Gray. Wild Chess.

135. *Setaria glauca* Beauv. Foxtail. Pigeon Grass.
Common in cultivated fields.

136. *Cenchrus tribuloides* L. Bur-Grass.
Sandy soil, found principally on the Arikaree formation

137. *Stipa viridula* Tun Feather Grass.

138. *Agrostis vulgaris* With. [*Agrostis alba* L.] Red Top.
Scattering here and there.

139. *Bouteloua oligostachya* (Nutt.) Torr. Grama Grass.
Found only in patches.

140. *Buchloe dactyloides* Engelm. [*Bulbilis dactyloides* (Nutt) Raf.] Buffalo Grass.

141. *Elymus canadensis* L. Nodding Wild Rye.

142. *Poa tenuifolia.* [*Poa buckleyana* Nash. Buckley's Spear Grass.]
Very common.

143. *Chrysopogon nutans* Benth. [*Chrysopogon avenaceus* (Michx.) Benth.] Wood Grass. Indian Grass.

144. *Festuca ovina* L. Bunch Grass. Sheep's Fescue Grass.

145. *Agropyron repens* (L.) Beauv. Couch, Quitch or Quick Grass.

146. *Calamagrostis canadensis* (Michx.) Beauv. Blue-joint Grass.
Common in wet places.

Equisctaceae:

147. *Equisetum arvense* L. Horse-tail.
Ring Thunder springs and in all the low swampy places of the reservation.

Birds.

While United States Indian teacher of the White Thunder Day School of the Rosebud Indian Reservation in 1904, I took notes on the occurrence and habits of the birds that chanced to visit the region. These I give below:

Gaviidae. Loons.

1. *Gavia imber* Gunner. Loon. Migratory; rare.

Laridae. Gulls and Terns.

2. *Larus delawarensis* Ord. Ring-billed Gull.
   I saw only one individual of this species.
3. *Hydrochelidon nigra surinamensis* (Gmel.) Black Tern.
   A male and female of this species were killed by an Indian of the camp who brought them to me for identification, remarking that they were sea birds.

Pelecanidae. Pelicans.

4. *Pelecanus erythrorhynchus* Gmelin. American White Pelican.
   An Indian of the camp killed a male pelican, skinned it and brought me the skin. I did not see the live bird.

Anatidae. Ducks, Geese and Swans.

The species of this family, given below, commenced appearing March 2, and commenced to go south August 21. None made residence in the region. But few crossed the area in the spring, they going farther to the east. More passed in their southern journey. The journey south was much prolonged on account of the warm fall, the birds seeming in no hurry to leave.

Unlucikly there was but little water in the vicinity of the author's location; consequently he had the opportunity of obtaining but a few specimens for identification.

5. *Anas boschas L.* Mallard. Abundant in migration.
6. *Anas obscura* Gmelin. Black Duck.
   I killed the only specimen I saw of this species.
7. *Nettion carolinensis* (Gmel.) Green Winged Teal.
8. *Querquedula discors* (L.) Blue Winged Teal.
   This species of birds together with that of *N. caroli-*

nensis constituted the greater majority of the ducks that passed over the region within the year.

9. *Querquedula cyanoptera* (Vieillot.) Cinnamon Teal. Rare in migration.

10. *Spatula clypeta* (L.) Shoveler. A common migrant.

11. *Dafila acuta* (L.) Pintail. A common migrant.

12. *Charitonetta albeola* (L.) Butter Ball. Not common in migration.

13. *Aythya vallisneria* (Wilson). Canvasback. Migratory; common.

14. *Aythya affinis* (Eyton). Lesser Scaup Duck. Not common in migration.

15. *Aythya collaris* (Donovan). Ring-necked Duck.

I saw but one specimen of this species. This I flushed at the edge of the school dam.

16. *Erismatura jamaicensis* Gmelin. Ruddy Duck.

17. *Chen hyperborea* (Pallas). Lesser Snow Goose.

A common migrant.

18. *Branta canadensis* (L.) Canada Goose. Common.

19. *Branta canadensis hutchinsi,* Sw. and Rich. Hutchins' Goose.

But one flock of these geese were seen.

20. *Branta bernicla* (L.) Brant or Barnacle Goose. Rather common in migration.

21. *Olor columbianus* (Ord.) Whistling Swan.

A flock of these swans were reported on White River.

22. *Fulica americana.* American Coot. Very common.

Ardeidae. Herons, Bitterns, etc.

23. *Botaurus lentiginosus* (Montagu.) Bittern.

I flushed this bird several times about the school pond. but I was unable to find a nest.

24. *Ardetta exilis* (Gmelin.) Least Bittern. Not common.

Gruidae. Cranes.

25. *Grus americana* (L.) Whooping Crane. Migratory; rare.

26. *Grus canadensis* L. Little Brown Crane. Common in migration.

27. *Grus mexicana* (Müller). Sandhill Crane; migratory; common.

These cranes, like the ducks, commenced crossing the region in the early days of March and commenced their southern trip across the same in the closing days of August, but unlike the ducks, about as many crossed the region in the spring as in the fall. But few of these birds alighted. Those that did seemed to prefer the high points to the water courses and low ground, the high points being the uninhabited areas.

Rallidae. Rails, etc.

28. *Rallus elegans* Audubon. King Rail.

I flushed this bird several times, but looked arduously for its nest without success.

29. *Rallus virginianus* L. Virginia Rail.

This bird is a common migrant, but evidence that it is a summer resident is wanting.

30. *Porzana carolina* (L.) Sora. A rare summer resident.

Scolopacidae. Snipes, Sandpipers and Curlews.

All of the species of this family given below, are common migrants and rare residents of the region, except the *Pectoral and Bartraminian* sandpipers and the Stone Snipe which are common residents. The *Bartraminian* Sandpiper nests in the upland region, the *Pectoral Sandpiper* and the Stone Snipe frequent the water holes.

31. *Tringa maculata* (Vieillot.) Pectoral Sandpiper or Snipe.

32. *Totanus melanoleucus* (Gmelin). Yellow Legs.

33. *Totanus flavipes* (Gmelin). Lesser Yellow Legs.

34. *Totanus semipalmatus.* Stone Snipe.

35. *Tringoides macularius.* Spotted Sandpiper.

36. *Helodromus solitarius* (Wilson). Solitary Sandpiper or Tattler.

37. *Bartramia longicauda* (Bechstein). Bartramian Sandpiper.

38. *Actitis macularia* (L.) Spotted Sandpiper.

39. *Numenius longirostris* Wilson. Long-billed Curlew.

40. *Numenius borealis* (Forster). Eskimo Curlew.

The last two species were well represented on the Butte Creek flats in June.

Charadridae. Plovers.

41. *Aegialitis vocifera* (L.) Kill-deer. A common summer resident.

Tetraonidae. Grouse, Partridges, Quail.

42. *Colinus virginianus* (L.) Bob White.

This bird is a rare resident of the reservation. I flushed but two on the reserve within the year. They, however, are an abundant resident over the line in the farming districts of Nebraska.

43. *Bonasa umbellus* (L.) Ruffled Grouse. A rare resident.

44. *Tympanuchus americanus* (Reichenbach). Prairie Hen.

This bird is a very common resident of the uplands, but is a rare resident in the valleys. It prefers to keep shy of the settlements.

45. *Pedioecetes phasianellus campestris* Ridgway. Prairie Sharp-tailed Grouse. A very common resident.

Columbidae. Pigeons.

46. *Zenaidura macroura* (L.) Mourning Dove.

The doves are common throughout the reservation, but most numerous in the White River valley region. Here droves of doves fly about all day long in the fall.

Falconidae. Falcons, Hawks, Eagles, Kites.

47. *Accipiter cooperi* Bonaparte. Cooper's Hawk. Resident, common.

48. *Buteo borealis* (Gmelin). Red Tailed Hawk. Resident, common.

49. *Buteo lineatus* (*Gmelin*). Red Shouldered Hawk. Resident, common.

In the fall the hawks of each of the three species mentioned above collect together in flocks and fly about the country in that manner for a considerable time before migrating. There are no or few hawks of any kind in the region in the winter season.

50. *Aquila chrysaetus* (L.) Golden Eagle.

This bird is common throughout the year, but more common in winter. It is from the feathers of this eagle and those of the Bald Eagle, next below, that the Sioux make their war-bonnets and other feathered regalia and paraphernalia. It takes a good horse to buy the feathers of one eagle on the reservation.

51. *Haliaetus leucocephalus* (L.) Bald Eagle. Common.

This bird with the Golden Eagle feeds principally on prairie dogs, hence it is a benefit to the region.

52. *Falco rusticolus* (L.) Gray Gyrfalcon.

But one individual of this species was seen by the author in the year.

53. *Falco mexicanus* Schlegel. Prairie Falcon. Rare.

54. *Falco columbarius* (L.) Pigeon Hawk. Not common.

55. *Falco sparverius* L. American Sparrow Hawk. Resident; abundant.

Bubonidae. Horned Owls, etc.

56. *Syrnium nebulosum* (Forster). Barred Owl. Common.

57. *Megascops asio* (L.) Screech Owl.

This owl could be heard nearly every night throughout the summer season. Its favorite haunts seemed to be the timbered region along the creeks. When putting in the school fence the children ran onto two of these birds and immediately advised me of their presence. Our work was done for that day. Not a child would proceed with the work. I asked them why they would not work, and they said: "Me no go where owl be, owl (image of) death." I learned afterwards that the Sioux, like most Indians, consider the owl the evil spirit of death, and that when it screeches or hoots it is calling some one to die.

58. *Bubo virginianus* (Gmelin). Great Horned Owl.
When doing research work in geology in the Robinson Bad Lands in July, I came onto two of these birds sitting on a branch of a leaning red cedar, back in a narrow, deep ravine. The birds did not see me till I was right under them. I tried to get them for specimens in my collection, but as I did not have my gun with me they escaped. I searched for a nest, but was unable to find any. These are the only birds of the species seen.

59. *Speotyto cunicularia hypogaea* (Bonaparte). Burrowing Owl.
These birds are abundant in the prairie dog town districts. Peculiar for an owl, on hot days they come out of their burrows and sun themselves, sitting usually on fence posts if there are any near their place of residence.

Picidae. Woodpeckers.

60. *Dryobates villosus* (L.) Hairy Woodpecker.
This bird is a common resident both in summer and winter. Both in the fall and in the spring they are usually found in company with the Long-tailed Chickadee.

61. *Dryobates pubescens* (L.) Downy Woodpecker. A common resident.

62. *Sphyrapicus varius* (L.) Yellow-bellied Sapsucker. Rare.

63. *Melanerpes erythrocephalus* (L.) Red-headed Woodpecker. Rare.

64. *Melanerpes carolinus* (L.) Red-bellied Woodpecker. Common.

65. *Colaptes auratus luteus* Bangs. Flicker. Very common

Caprimulgidae. Night Hawks. Goatsuckers.

66. *Chordeiles virginianus henryi,* Cass. Western Night Hawk.
This bird is one of the most common large birds of the country. I found a nest in the potato patch. The female was on it when found. She dragged herself

over the ground, fluttered and squacked. At length I scared her so that she flew. And I then found that she had been dragging her eggs under her as she dragged herself over the ground. There was nothing, however, that could be called a nest except a little hollowed out place. There was neither stick, straw nor feathers to mark the place. The eggs were two in number and were of a dirty mud color.

Trochilidae. Humming Birds.

67. *Trochilus colubris* L. Ruby-throated Humming Bird. Common in summer.

Tyrannidae. Tyrant Flycatchers.

68. *Tyrannus tyrannus* (L.) Kingbird. Summer reident; abundant.

69. *Sayornis phoebe* (Latham). Phoebe. Pewee.
I saw but few of these birds, and no nests at all.

70. *Contopus virens* (L.) Wood Pewee. A common summer resident.

71. *Contopus richardsoni* (Swainson). Western Wood Pewee. A rare summer resident.

Corvidae, Magpies, Crows, Jays.

72. *Pica pica hudsonica* Sabine. American Magpie.

This bird is a resident throughout the year, but more numerous in winter.

There were so many of these birds about the school in spring that it became necessary to kill some of them, because they were making themselves such a pest. I had killed only a few when all disappeared. I thought that they had migrated from the region, but later I found them nesting in White River valley. They knew that they were being killed and so left the immediate vicinity of the school.

These birds alight on the backs of horses and cattle and peck holes through the hide and eat the flesh out. Still worse, if a horse has a sore back made by saddle or harness, they will perch themselves on him and eat the flesh out till he dies. If the poor creature tries to swith or rub off the pesterer, the bird simply hops to the other side of the animal and begins to peck there. This is kept up until the tortured animal gives up in despair. The bird then eats his fill. The work of these birds, however, is not always a detriment. I have seen them pick grubs from cows' backs by the hour.

They seem to possess considerable intelligence, if it can can be said that a bird possesses intelligence. As is seen above they left the school when they found that their kind was being killed, there. Again, they were often seen to alight in the yard and chase the chickens from their feed, one chasing while the others ate.

73. *Cyanocitta cristata* (L.) Blue Jay. A common resident.

74. *Corvus americanus* Audubon. American Crow. An abundant resident.

Icteridae. Blackbirds, Orioles, etc.

75. *Agelaius phoeniceus* (L.) Red-Winged Blackbird.

These birds are very abundant in migration, but in residence rare; I found only one nest.

76. *Agelaius phoeniceus fortis* Ridgway. Northern Redwing. Common in migration.

77. *Xanthocephalus xanthocephalus* (Bonaparte). Yellow-headed Blackbird.

This bird is an abundant resident as well as a migrant.

78. *Molothrus ater* (Boddaert). Cowbird. An abundant summer resident.

79. *Sturnella magna* (L.) Meadowlark. An occasional resident.

80. *Sturnella magna neglecta* (Audubon). Western Meadowlark.

This bird is an abundant resident. While it looks like *S. magna,* it is very different in action. Its song is "Tung-tung-tungah-til'-lah-tung;" its warning call, "Tuck;" its warning whistle, "Whah-o;" its sympathetic call, "Tyar." It flies by a trembling flutter of the wings.

81. *Icterus spurius* (L.) Orchard Oriole. Resident in summer.

82. *Icterus galbula* (L.) Baltimore Oriole. A summer resident.

83. *Quiscalus quiscala aeneus* Ridgway. Crow Blackbird. Abundant in summer.

Fringillidae. Finches, Sparrows, etc.

84. *Ammodramus sandwichensis savanna* Wilson. Savanna Sparrow. Very common.

85. *Ammodramus savannarum alaudinus* Bonaparte. Western Savanna Sparrow.

86. *Ammodramus savannarum passerinus* Wilson. Grasshopper Sparrow.

87. *Spizella socialis* (Wilson). Chipping Sparrow.

88. *Spizella pusilla* Wilson. Field Sparrow. A common summer resident.

89. *Junco aikeni* Ridgway. White-winged Junco. A rare winter visitor.

90. *Junco hyemalis* (L.) Slate-colored Junco. Common in winter.

91. *Junco hyemalis oregonus* Townsend. Oregon Junco. Common in winter.

92. *Calamospiza melanocorys* Stejneger. Lark Bunting.
These birds are an abundant resident in summer. Both in fall and spring they fly around in flocks like blackbirds. In the summer they are seen in pairs only.

93. *Passer domesticus* (L.) English Sparrow.
These birds are just beginning to enter the region. They are driving the summer bluebird out of the country wherever they appear.

94. *Piranga erythromelas* Vieillot. Scarlet Tanager. Common in summer.

95. *Piranga rubra* (L.) Summer Tanager. Summer resident. Rare.

Hirundinidae. Swallows.

96. *Petrochelidon lunifrons* (Say.) Cliff Swallow. Summer resident; common.

97. *Hirundo erythrogaster* Boddært. Barn Swallow.

These birds are an abundant summer resident in the vicinity of the Ring Thunder Day School; I saw but few of them at any other place.

98. *Clivicola riparia* (L.) Bank Swallow. Very common along the banks of White River.

Laniidae, Shrikes.

99. *Lanius borealis* Vieillot. Northern Shrike. Common in winter.

Mniotiltidae. Wood Warblers.

100. *Dendroica aestiva* (Gmelin) Yellow Warbler. An abundant resident.

101. *Seiurus motacilla* (Vieillot). Louisiana Water Thrush. Rare.

102. *Setophaga ruticilla* (L.) American Redstart. Common in summer.

Troglodytidae. Mocking Birds, Thrashers, Wrens.

103. *Mimus polyglottos* (L.) Mocking-bird. Common in summer.

104. *Salpinctes obsoletus* Say. Rock Wren. Common in broken districts.

105. *Harporhynchus rufus* (L.) Brown Thrasher. Common in summer.

106. *Troglodytes aedon aztecus* Baird. Western House Wren. Rare.

Paridae. Chickadees, etc.

107. *Parus atricapillus* (L.) Chickadee.

108. *Parus atricapillus septentrionalis* Harris. Long-tailed Chickadee.

The two species of chickadees above are very common, the latter being the most abundant. They are found most usually in company with the hairy woodpeckers and creepers. They are very busy birds and are always keeping up their peculiar chatter. They seem to prefer the elm trees to all others when looking for food. They appear in August and remain until the following May.

Turdidae. Thrushes, Robins, Bluebirds.

109. *Hylocichla mustelina* (Gmelin). Wood Thrush. Rare.
110. *Hylocichla aonalaschkae pallasii* Cabanis. Hermit Thrush.
    This bird is very rare; I found but one nest.
111. *Merula migratoria* (L.) American Robin.
    The robin, though one of the first migrant birds to appear in the spring and the last to leave (the school children captured one December 20th), they are very rare.
112. *Merula migratoria propinqua* Ridgway. Western Robin. Rare.
113. *Sialia sialis* (L.) Bluebird. Common.

Below is a list of the amphibians, reptiles and mammals seen on the Rosebud Indian Reservation from January 7, 1904 to March 20, 1905.

1. *Bufo lentiginosus* Shaw. Toad. Not common.
2. *Rana pipiens* Schreber. Common Frog. Very plentiful.
3. *Rana clamitans* Latreille. Green Frog. Rare.
4. *Thamnophis sirtalis* (L.) Garter Snake.
5. *Liopeltis vernalis* (De Kay). Grass Snake. Rare.
6. *Pituophis sayi* (Schlegel.). Western Bull Snake.
    But one individual of this species was seen.
7. *Sistrurus catenatus* (Rafinesque). Prairie Rattle Snake.
8. *Crotalus horridus* L. Common Rattle Snake.
    The last two species are very numerous everywhere. Besides they have dens in the Rattle Snake Buttes. Here the snakes often come from their dens on warm days in the fall and bask in the sun by thousands. It is absolutely unsafe to venture into this butte region except in cold weather.
9. *Chelydra serpentina* L. Snapping Turtle.

1. *Lepus nuttalli mearnsi* Allen. Gray Rabbit.
    Not numerous on the reservation.
2. *Lepus campestris* Bachman. Jack Rabbit.
    This rabbit is found principally in the bad land regions and places remote from the "camps," as the Indian villages are called.

3. *Zapus hudsonius* Zimmermann. Jumping Mouse.

But one individual of this species was obtained. I saw the house cat with it, so took it away from her and identified it.

4. *Thomomys talpoides* Maxmilian. Northern Pocket Gopher.

5. *Fiber zibethicus* (L.) Muskrat.

This little animal is very numerous in the lakes and ponded areas of the reservation, whether the ponds are artificial or natural.

6. *Microtus hydeni* Baird. Meadow Vole.

7. *Microtus austerus* Leconte. Meadow Vole.

8. *Arvicola riparius* Ord. Meadow Vole.

The last three species of meadow voles are very common. They are by far the most numerous animals of the region. When the grass is burned off of the prairie in the spring, their roadways are found to almost literally cover the ground, especially in the dry ravines.

9. *Castor canadensis* Kuhl. American Beaver.

This animal is fast becoming extinct, notwithstanding the fact that the Indian Agent has forbidden the killing of them.

10. *Spermophilus tridecemlineatus* (Mitchell). Striped Gopher.

This gopher is quite common, but not numerous as in Iowa.

11. *Sorex personatus* Isadore Goeffry St. Hilaire. Shrew.

The cat brought me the specimen here identified, February 20, 1905.

12. *Scalops aquaticus machrinus* Rafinesque. Prairie Mole. Not common.

13. *Vespertilio fuscus* Beauvois. Brown Bat.

14. *Odocoileus americanus macrourus* Rafinesque. White-tailed Deer.

This deer is practically extinct on the reservation, a a few coming in from the Big Bad Lands constitute about all that ever reach the region at all.

15. *Antilocapra americana* (Ord.) Rocky Mountain "Antelope." Prong-horn.

A few bunches of these animals still remain on the reservation. A bunch of five were seen on the Antelope Creek flat near Turtle Butte in August, 1904. They are said to be more plentiful in the eastern part of the region and in Gregory County beyond the reservation limit.

16. *Procyon lotor* (L.) Common Raccoon.

17. *Mephitis hudsonica* Richardson. Great Northern Skunk.

Taxidea americana (Boddaert). American Badger.

These animals are rather plentiful on the Indian lands. They live principally in the vicinity of the prairie dog towns. Their food is, for the most part, striped gophers and prairie dogs.

18. *Mustela pennantii* Erxleben. Marten.

These animals are migrating southward. They made their first appearnace in the Rosebud region last year. The settling up of the Canadian country to the north is probably the cause of their migrating. In their new habitat they live principally in the prairie dog town regions, using the abandoned prairie dog holes as their homes. Their food is the prairie dog, whole prairie dog towns being exterminated by them.

19. *Lutra canadensis* (Schreber). American Otter. Rare.

20. *Lutreola vison* (Shreber.) Mink.

21. *Putorius longicauda* (Bonaparte.) Long-tailed Weasel.

A stuffed specimen of this species is now in Mr. E. Jordan's store at Butte Creek, on the reserve.

22. *Putorius cicognani* (Bonaparte.) Small Brown Weasel. Not common.

23. *Canis latrans* Say. Coyote.

These animals are very numerous everywhere. They are bold, coming to barnyards and killing chickens at mid-day.

24. *Canis nubilus* Say. Gray Wolf.

This animal is found principally in the bad land regions; only five were seen in the vicinity of the White Thunder School within the author's stay there.

25. *Cynomys ludovicianus* Prairie Dog.
The towns of this little animal are found scattered over the whole region, the vegetation being partly or wholly destroyed in their vicinity, depending upon the length of time the respective town has remained there.

26. *Lynx canadensis* (Desmarest). Canada Lynx. Not common.

27. *Felis concolor* (L.) American Panther.
Occasionally seen in the bad land regions.

Drainage in South Dakota.

PROF. A. B. MCDANIEL.

The Preliminary Steps to Its Accomplishment.

The state of South Dakota is, geographically speaking nearly divided into halves, longitudinally by the Missouri River. These two sections are quite different in their physical character; the western section being quite hilly and rugged in aspect, while east of the river the surface is very flat and has the appearance of one great tableland, broken here and there by the varied meanderings of valley and ridge. In many sections of the eastern part of the state, these valleys widen out into basins of considerable width and these low places, not having sufficient outlet for water, which is received by them from their own surfaces and small streams emptying into them; are always in such a wet condition that cultivation is uncertain and often impossible. The only vegetation which is practicable is reeds, rushes, cane and wild grass. A crop of the coarse marsh grass is often difficult or impossible to secure on account of the wet condition of the soil.

Here is before us a brief pen picture of the condition of hundreds of thousands of acres or about 640 square miles of land in this part of the state. Thousands of settlers are coming into the state from adjoining states and all the available land is rapidly being taken up and improved. The day is not far distant in the future, when land will become scarce and its value greatly increase. Then the improvement and utilization of these great swampy wastes will become a vital question to the people of the state. Even now, in many such places, where large areas of "bottom" land are poorly drained by sluggish streams and subjected annually to periods of serious overflow, the growth and even mere existence of many towns and small agricultural communities are dependent on the productivity of this land. It soon becomes a matter of deep public concern that such land with ready market and transportation facilities, be properly drained.

Then the people can go ahead and establish serviceable roads, improve their farms and cultivate the land in the most approved manner.

Now when a community has decided that its land, wholly or in part, needs drainage, the next step is the determination of the character and amount of such work. Also the method of obtaining it and the cost to the land owners to be benefitted by such an improvement. Where and to whom shall the community turn for aid and advice in this matter; which will be of real value and service? For over a half a century the Federal Government has had the subject of drainage under consideration as it is well known that in this country are 100,000 square miles of marsh and swamp land; "the dormant wealth of the nation!" In 1850, the Swamp Land Act was passed and since then the various states acting independently, have reclaimed more than 82,000,000 acres of such land.

The U. S. Geological Survey for 15 years past has been carrying on extensive topographic and hydrographic surveys in order that the people of the country may have accurate information concerning the water supply, underground currents and artesian wells. The published reports of these investigations contain an immense amount of information of value to the drainage of swamp lands.

A few years ago under the office of experiment stations of the U. S. Department of Agriculture, an office of irrigation and drainage investigations was established. The relation of this department of the government service to a community in need of drainage is as follows. The citizens of this community draw up a petition applying to the Department for aid in their proposed plan for drainage. The Department in response sends out an experienced drainage engineer, who makes a rapid preliminary survey or inspection of the district in question and makes a report to the Department. If the report shows that the project is rational and practicable, then the Department sends out an engineering party, which makes a thorough preliminary survey of the district and from this report giving a comprehensive plan for the drainage of the land and an estimate of the cost.

Now, the community has a definite basis to work upon and with the nature of the work and its costs and benefits accurately and clearly defined, it only remains for the harmonious co-operation of a large majority of the land owners before further action. This should and must be embodied in a petition, describing the territory to be drained and the ditches to be constructed. Such a petition when accompanied by a sufficient bond and filed with the auditor, brings the matter under the jurisdiction of the Board of County Commissioners. The Board then views the district and action is taken at the next regular meeting and the petition is either granted or rejected, as the judgment of the Board decrees after a due consideration of all the circumstances and conditions governing the work. If the petition is granted, the Board the appoints an Engineer who makes a location or final survey of the ditch or ditches in preparation for the construction. This final survey is based upon the report of the preliminary survey. The work is then duly advertised and bids are received, considered and the contract let to the lowest responsible bidder. The successful contractor soon begins operations as required by the contract.

Let us consider an actual case of drainage work, which is now being constructed in the southeastern corner of the State.

THE CLAY CREEK DRAINAGE DITCH.

This ditch will be the main artery of a system of ditches located in the "bottom" lands of the Missouri River in Clay and Yankton Counties, and will drain about 70,000 acres of this low land.

Just imagine a very level plain about ten miles wide and twenty miles long with a slope to the south and east of about one foot in a mile and you will have a mind picture of this great area of bottom land as it lies between the Missouri and James Rivers on the south and west and the bluff or table land on the north and east.

During the spring or rainy season, the lower sections of the "bottom" are flooded with water and the only vegetation which grows is cane, reeds and coarse marsh grass. The higher sections are used for hay, which in dry and very favorable seasons can be cut. Along the bluff slopes and higher levels near the line of the C. M. & St. P. R. R. the land is cultivated and corn and grain are raised. During very wet or overflow seasons the lower levels of this cultivated land are covered with water and the crops are lost.

The natural drain of this area is a small sluggish stream known as Clay Creek, but this has never been sufficient to properly drain this land. So far back as 1887 the farmers of this district co-operated and constructed a small ditch, which used the creek as a basis and in as nearly a straight line as practicible, followed the natural drainage basin to a point near the outlet of the creek into the Vermillion River. This ditch, however, was constructed too small, and during the past twenty years has been gradually filling up with fine earth and vegetable matter carried along and deposited by the water.

During the early part of the year of 1904, a petition from the land owners of this territory, sent to the Department of Irrigation and Drainage Investigations of the U. S. Department of Agriculture, resulted in the preliminary survey, which was made by a party from this department of government service in August of this year. This survey was embodied in a report which showed clearly and conclusively that this broad valley could be satisfactorily drained by means of ditches of sufficient size.

After considerable discussion and uncertainty, action was begun in the early part of the year 1908 by the letting of the contract for the construction of the main ditch, to the Pollard & Campbell Dredging Co., of Omaha, Neb. At once the construction of the dredges began.

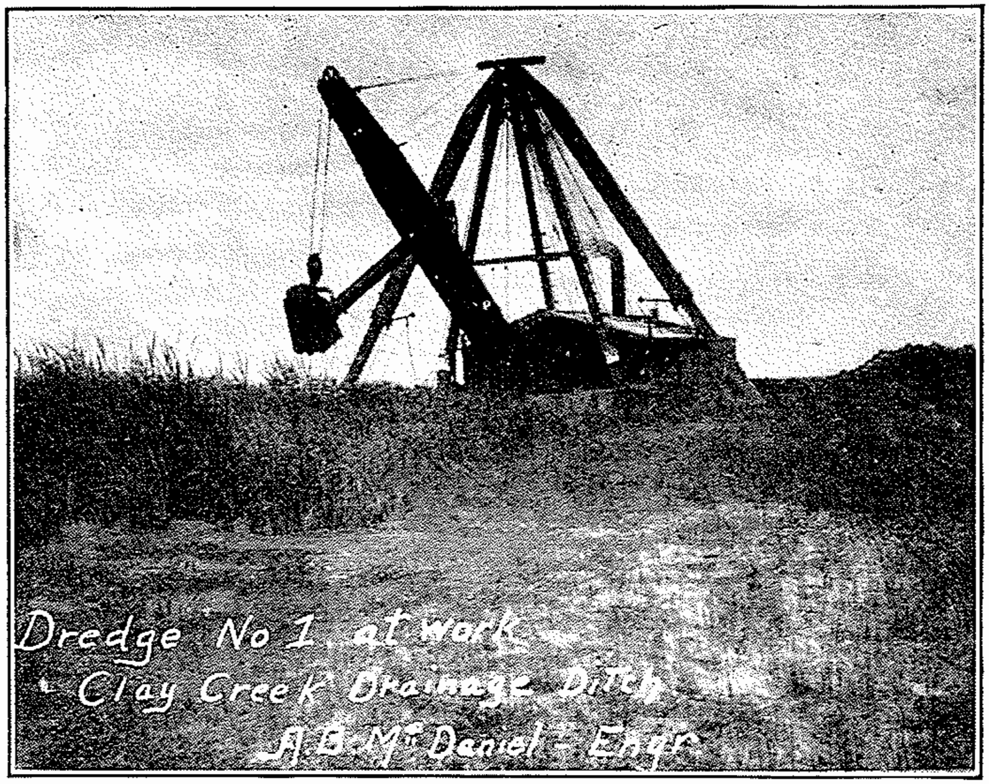
First, house boats were built for the men who were to build the dredges, to live in. These were two story and 16 feet wide and 40 feet long; the lower story serving as a dining room, kitchen and storage room, and the upper story as sleeping rooms. Meanwhile, the lumber and machinery for the dredges was hauled to the side of the creek and the erection of the hull of the dredges begun. The hull is a flat-bottom and square-ended boat built of heavy timbers and well spiked and bolted together. The joints were well calked with oakum and hot tar and then the boat was launched into the creek by skidding it off sideways. On the floor of the boat were placed the boiler and the hoisting and swinging engines for operating the great crane. This is a large boom about 70 feet long, pivoted at its lower end to the front of the boat and carrying on its upper end the dipper, which scoops out the dirt from the ditch and then deposits it along the sides.

While the construction of the dredges was in progress, about the latter part of April, the County Commissioners of Clay and Yankton Counties who had this work in charge, appointed Prof. A. B. McDaniel of the College of Engineering of the University of South Dakota, as engineer in charge of the survey and construction of the ditch. On the first day of May Prof. McDaniel, with two of his students, began the survey for the final location of the ditch. The center line and the grade were first determined and then profiles were drawn and the grade at the bottom of the ditch was established. Cross sectioning was then done, which comprised the location of the sides of the ditch and the width of the berm and the right of way. Wading, day after day, through sticky gumbo and water up to the waist and often deeper, and drenched by frequent rains; the life of the drainage engineer is not altogether pleasant and becomes rather aquatic in character.

Along about the middle of July Dredge No. 1, which was being built at the upper end of the proposed ditch, near Volin, was nearing completion. A boat 30 feet wide, 87 feet long and 6 feet deep, carrying a large horizontal locomotive boiler of 60 H. P. and separate hoisting and swinging engines which manipulated the crane, on whose outer end was suspended the 1¾-yard dipper. For nearly two months, ten men had labored incessantly to erect this great machine at an expense of about $5,000. Eight miles farther down the creek another boat, 35 feet wide, 96 feet long and 6 feet deep was being built and here as well, the sound of the hammer and the roar of the forge were seldom silent.

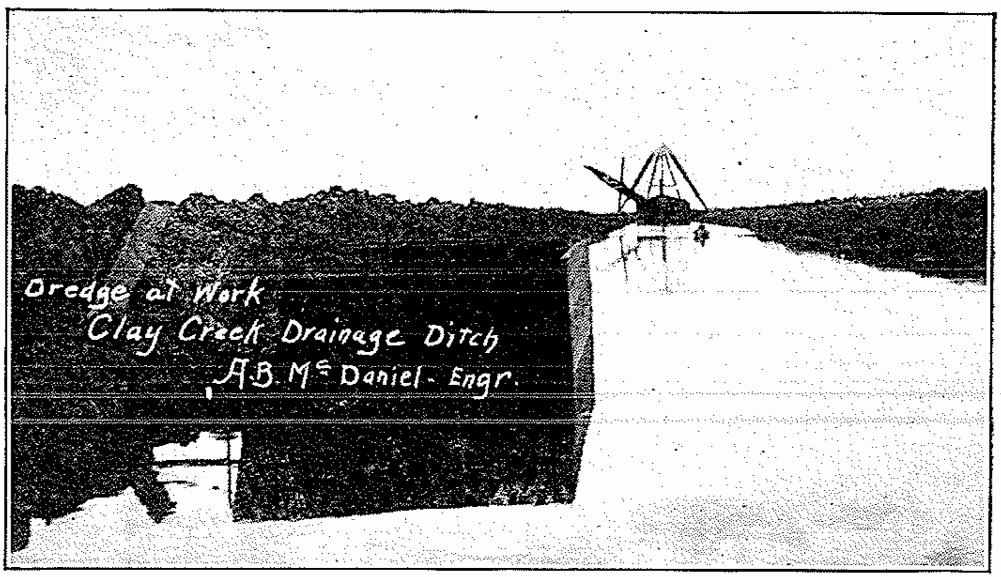
Finally on Dredge No. 1 the great inclined arms or spuds, which are on the sides of the boat near the front, and rest on the banks of the ditch and steady the boat while the great crane is swinging around with its load, were erected into place and actual digging at last began.

Plate 1.



Front view of Dredge No. 1. at work

Plate 2.



Rear view of Dredge No. 1, showing size of channel excavated

Swiftly and smoothly, like the movement of a great serpent, the dipper dived into the shallow water and emerged with a heaping load of earth. The crane swung around to the bank and when about 10 feet from the edge, the bottom of the dipper swung down and out slipped the huge mass of dripping earth. Down again plunged the dipper, and out again, swinging to the other bank, where the excavated material was quickly and silently deposited. Twice during the space of a minute did the operation continue and for 24 hours in each day and 7 days in each week this tireless monster works on. Five men are required to work a dredge of this size and six tons of coal a day are necessary to feed the boiler. The men work in shifts of 12 hours each, with intervals of rest for meals. One shift of five men sleeps while the other works. The houseboat is dragged along in the rear of the dredge, but at a sufficient distance so that the noise and dirt of the latter will not inconvenience and disturb the occupants of the boat.

Soon both dredges will be working and the ditch will grow at the rate of 500 feet a day; that is, the progress of each dredge will be about 250 feet daily and will excavate about 60,000 cubic yards of material during a month.

The ditch will have a total length of nearly 16½ miles and having a cross section of uniformly varying size from the beginning to the end. At the beginning, the width at the bottom will be about 30 feet and at the top about 38 feet; while the depth will be about 9 feet. At the end, the width of the bottom will be about 42 feet, and at the top about 56 feet, while the depth will be about 13 feet. This will give a trapezoidal cross section with side slopes of ½ to 1.

The average velocity of the water flowing through the ditch, when the latter is about ¾ full, will be about 4 feet per second or about 2¾ miles per hour. This will insure the flushing out of the ditch and the prevention of any serious deposition of material which would in time fill up the ditch.

The Lewison Drainage Ditch.

In Union County, the history of the Clay Creek Drainage Ditch is repeated in the so-called Lewison ditch.

In the year 1877, by an act of the Territorial Legislature, a ditch was dug in Brule township connecting the southern end of Norwegian Lake with the Big Sioux River. This was a double ditch with the excavated material placed on a wide bench separating the two channels. As completed, this ditch did not reach the Norwegian Lake, but had its beginning about one mile south of its southern extremity. This ditch, however, like its neighbor in Clay County, proved to be too small and soon filled up.

Then in the fall of 1894 another ditch was constructed along the line of the original double ditch. This was a single channel dredged out of one of the former channels and the excavated material was deposited in the other of the two former channels.

After thirteen years the landowners of this district found that again the ditch was insufficient to properly drain their broad expanse of bottom land, and they petitioned the Board of County Commissioners for a new ditch. The petition was granted and the ditch ordered. In July, 1908, the contract for the construction was let to J. A. Braumbaugh of Elkhart, Indiana, and the erection of one of the dredges to be used is now (August, 1908) in progress.

This ditch is to follow the line of the two former ditches and to extend northwest through the Norwegian Lake to a point about three miles beyond the northern end of the lake.

The total length of the main ditch will be 8.96 miles. The cross section for about 5½ miles will be trapezoidal, with a bottom width of 8 feet and a depth of 14 feet, side slopes of 1 to 1. For the remainder of its length the ditch will have a bottom width of 4 feet. The grade of the bottom of the ditch will be .061 per cent or about 3¼ feet in a mile. The total estimated excavation is 230,000 cubic yards.

In addition to the main ditch there will be 8 laterals of a total length of about 20 miles. These are partly road ditches and average about 1½ miles in length, two of them being much longer and very crooked in alignment. These ditches will have a bottom width of 4 feet, and a depth of 2 feet at the start and 5 feet at the end. The total excavation for the 8 laterals is estimated at about 89,000 cubic yards.

The main ditch and the laterals will drain about 17,000 acres of low, wet bottom land and the Norwegian Lake with its area of about 92 acres.

PROJECTED WORK.

In addition to the projects which have just been described, there are several ditches which are under construction and in all stages of development from the petition to the letting of the contract.

In Clay County a large lateral of the Clay Creek Ditch, known as the Meckling Ditch, is being considered. It will have a bottom width of about 10 feet at the outlet and diminish in size as the upper end is approached. Its depth will vary from 3 to 5½ feet, and be about 5 miles long.

The Gayville Ditch will drain a series of sloughs which meander through the southern section of the Missouri River bottom in Clay County. This ditch will have a length of 20.5 miles; a depth of from 6 to 13 feet and a bottom width of 16 feet at the outlet diminishing in size as the upper end is approached. It will drain 32,000 acres.

In Union County there are several projects under way. The Schon Ditch in the northeast corner of the county will have a length of 1.33 miles; a bottom width of 4 feet and a depth of from 3 to 8 feet. It will have an estimated yardage of 18,500 cubic yards and will drain 1,141 acres. This ditch has been ordered by the Board of County Commissioners and bids advertised for, but as yet no bids have been received.

The Dennison Ditch in the southern section of the county, near Elk Point and Jefferson, will have a length of 4½ miles, a bottom width of 4 feet and a varying depth of from 2.8 feet to 8 feet. It will drain about 5,440 acres.

In Sioux Valley township the farmers have petitioned for a ditch to drain the country tributary to the Union Creek for a distance of about 2 miles.

In Richardson township the land owners have petitioned for a ditch to drain Nixon Lake into the Bix Sioux River. This would require a ditch about 1 mile in length.

The Benefits Resulting From Drainage.

"The soil is the farmer's business capital." He has come into its ownership by various means: inheritance, gift, or most likely by the exchange of money. He must now depend entirely upon it for his future subsistence and welfare. His future success and prosperity depend upon the intelligence and industry which he expends in the disposition and development of this capital.

Time was, about two decades ago, when the farmer cultivated in a crude and unintelligent way the part of his land most suitable for his various crops. Now, however, with the wonderful and rapid development of this great country, land is becoming scarce and more valuable and these great areas of swampy, undesireable land must be used. Every acre of this land means to the farmer to-day, just so much dormant, unproductive capital. It means every year, the loss of just so much interest on his money and taxes.

A large and swampy piece of land is a blot on the landscape; a source of ill-health and perhaps a serious calamity to the people in the adjacent communities. This is well illustrated by the epidemic of anthrax which at present is prevalent in the Missouri River bottom in Clay and Yankton Counties. Hundreds of valuable horses and cattle are being lost at a loss of thousands of dollars, which could have been averted if this same amount of money had been wisely expended years ago in suitable drainage. These low, wet swampy areas are an ideal breeding place for germs and their carriers, of the most malignant and destructive character.

In the early part of this paper it was stated that the usual vegetation found on this low, swampy land were a coarse, rank marsh grass, reeds, cane and rushes. The higher levels of this character of land are used for pasture or hay, but it is subject to the uncertainty of the seasons, and in the best seasons the product is far less than it might be if well drained.

In such land as we find here on the Missouri River bottom, there is a surface soil of rich loam to a depth of 4 or 5 feet and under this a clayey subsoil. The surface being so level, and with no provision for sub or under-drainage, this subsoil is almost constantly wet, and when rain falls or snow melts upon the surface, the water not being able to drain off, sinks into the soil until it is filled and then stands on the surface. Here the water stands until it is evaporated by the sun and wind, which soon begin to drink up the sub-surface water and leave wide, gaping fissures and cracks, due to the shrinkage of the soil. After the surface soil has become sufficiently dry, the land may be ploughed, seed planted and growth begun if there is not too much rain. If the latter occurs growth will be seriously retarded or perhaps prevented. Mr. George E. Waring, Jr., in his work on "Sewerage and Land Drainage" clearly describes this as follows: "The first growth of the embryo plant (in the seed) is merely a change of form and position of the material, which the seed itself contains. It requires none of the elements of the soil and would under the same conditions, take place in moist sawdust as in the richest mould. The conditions required are the exclusion of light, a certain degree of heat, and the presence of atmospheric air and moisture. Any material which, without entirely excluding the air, will shade the seed from the light, yield the necessary amount of moisture, and allow the accumulation of the requisite heat, will favor the chemical changes which, under the circumstances, take place in the living seed. In proportion as the heat is reduced by the chilling effect of evaporation and as atmospheric air is excluded, will the germination of the seed be retarded; and in case of complete saturation for a long time, absolute decay will ensue and the germ will die."

If, however, as often may be the case, the weather is such that germination takes place and the corn or grain sprouts and begins to grow and then the early summer rains commence, and an unnatural development or weakly condition results. Later in the season the want of sufficient rain may cause the crop to be parched, on account of the baking of the roots, which naturally are repelled from the soggy, clammy sub-soil and extend to the surface. If, however, the usual rains are delayed and come at harvest time, the gathering of the crop may be delayed until it is greatly injured.

It is thus clearly evident that these bottom lands which are perhaps the most fertile of any in this great and prosperous commonwealth, should be drained and after considering what has been done in the past to reclaim the fens of England, the marshes of Holland, and the great areas in Illinois, Louisiana, Arkansas, Iowa and other of the states of our nation, it is certianly most feasible and practicable to drain the 400,000 acres of wet, swampy land in South Dakota, and thus add greatly to the wealth of the state.

The engineering problems connected with drainage are simple, as most of the lands are several feet above mean low water level of some water course that can be straightened, widened or deepened to afford sufficient outlet.

Levees can be built and ditches excavated with suitable machinery at a cost of from 7 to 16 cents per cubic yard. As to whether the cost of drainage will pay for the expense involved, let us consider the results of numerous such works in the neighboring states. Where large areas of swamp lands have been thoroughly drained by open ditches and tile drains; the cost ranges from $6 to $20 per acre, while in places where tile drainage was not required the cost has averaged about $4 per acre. From a thorough investigation of the cost of this work throughout the country, it would seem that a cost of $15 per acre would be a safe estimate for the complete and thorough drainage of low, wet land of this state. The market value of such land varies from $2 to $20 per acre, depending upon the location and prospect of drainage, with an average value of about $10 per acre. Similar lands in neighboring states, when drained, sell from $60 to $100 per acre, and when near large cities, as high as $400 per acre.

Now let us consider for a moment as to whether it will pay the people of South Dakota to drain their 400,000 acres of low, wet land:

Cash value of 400,000 acres, after thorough drainage, at $60 per acre		$24,000,000
Present value of this land at $10 per acre.	4,000,000	
Cost of drainage at $15 per acre	6,000,000	
	$10,000,00	
Value of land and cost of drainage		$10,000,000
Net increase in value		14,000,000

Thus by drainage, the State is enriched by $14,000,000 and each farmer benefitted has increased his capital stock by an amount equivalent to $35 an acre. These figures are not imaginary or guess work, but are based on results obtained in all the sections of this country where drainage has been carried on. In every case where thorough drainage has been planned and properly carried out, the value of the land has increased many fold. In many cases, as has been already noted concerning the early ditch work of this State; years of time and a great amount of money has been wasted because the work was not properly planned and was insufficient to afford adequate and complete drainage. The Boards of County Commissioners of the various counties of this State where drainage is necessary, should not be content with the services of a County Surveyor, unless he is a competent man, with several years' experience in this class of engineering work. They should profit by the costly experience of other states and past work in this state and first of all secure the services of a competent civil engineer, preferably one with good experience in this class of work.

The County Auditors, by corresponding with Hon. S. H. Lea, the State Engineer, at Pierre, or Prof. A. B. McDaniel, of the State University, at Vermillion, will be informed as to the securing of competent drainage engineers.

It is to be hoped that the farmers of this State, be their interests large or small, will acquaint themselves with the principles of drainage. The national government publishes bulletins for free distribution, on the progress of this work throughout the country. These may be obtained by application to the Department of Agriculture.

The College of Engineering of the State University at Vermillion now offers a course in Drainage and while this course is intended to train engineers for this field of engineering, it is open to all who wish to become informed on the subject.

Some Devonian and Silurian Fossils from Northeastern Iowa.

By Arthur L. Haines.

As the Devonian and Silurian deposits of South Dakota are of no great extent, it was thought advisable to obtain a collection of fossils from some other state which has extensive deposits in these fossils. So in the summer of 1906 the State Geologist of South Dakota authorized me to visit several localities in Iowa in order to make a collection for the museum of the State Geological Survey.

The places visited were, Rockford, Ia., Charles City, Ia., Waterloo, Ia., Decorah, Ia., and Waukon, Ia.

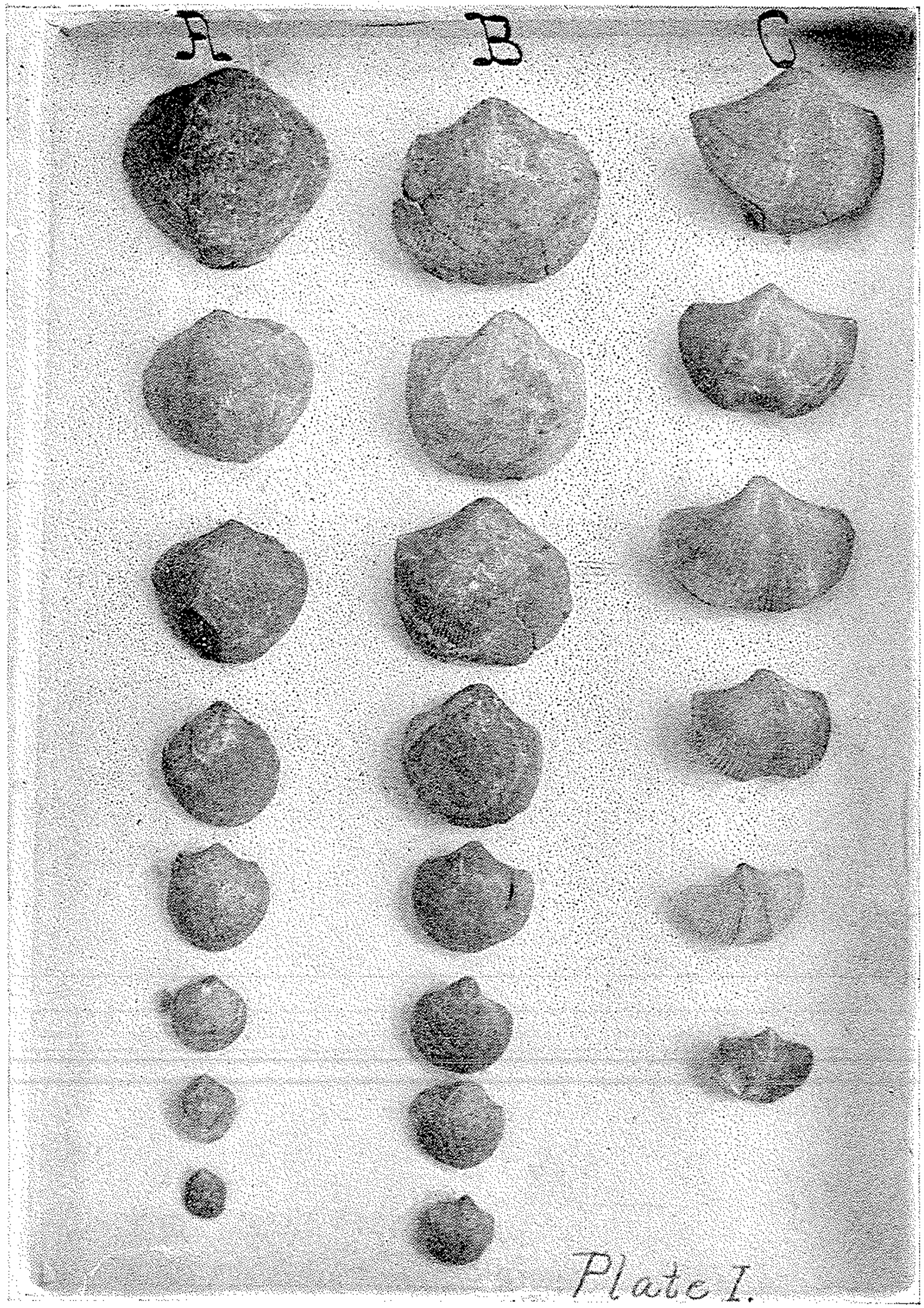
Deposits at Rockford, Iowa.

Two localities were visited at Rockford. One of these was at the bridge just south of the city. On both sides of the river is found a rather massive limestone containing many fossils, and are referred to the Devonian System, Hamilton Series.

This limestone does not weather as readily as the shale above, so few free specimens could be obtained. However, upon the upper surface of some of the layers, partly embedded in the calcareous matrix, are beautiful fossils, including brachiopods, corals, bryozoa crowded closely together, and in a very perfect state of preservation.

By far the greater part of the fossils obtained at Rockford, were collected at the brickyards, about a mile west of the city, as well as on the ridge of hills running to the southwest of the brickyards. These beds form the extreme upper members of the western Devonian System, and have been variously correlated with the New York series. It has been referred, by different geologists, to the several divisions of the Devonian System as the Chemung, Hamilton and Corniferous series, while others believe it

Plate 1



Atrypa recticularis

Spirifer Hungerfordi

Spirifer Whitneyi

cannot be referred to any of these, but that it stands alone as a new series to which the name Hackberry has been given.

It has been given various names, as Lime Creek shales, Rockford shales, Hamilton shales, etc. Although this series contains a number of species found in the Hamilton series, there is a marked difference peculiar to them, on account of which some are disposed to place them in a separate series.

The predominating fossils are brachiopods, of which the *Atrypa reticularis* is by far the most abundant. This form seemed to be able to thrive under almost any conditions. They are not as large as those found at Waterloo, Ia. Corals rank second in point of numbers, of which the *Pachyphyllum Woodmani* and *Campophyllum nanum* are good examples. Three miles to the southwest the *Campophyllum nanum* is the most abundant species. The *Pachyphyllum Woodmani* is found in the gullies and washes on the south and east slopes of the hills at the brick yards.

The exposure here has a vertical height of about 100 feet and consists of a rather dark colored argillaceous shale, which weathers readily upon exposure, producing a bluish clay suitable for brick and tile making, as well as leaving the fossils in a very perfect state, entirely free from the matrix.

Fossils may be obtained in very large quantities. The exposure faces toward the north and east and the whole slope as well as the top of the hill is crowded with fossils.

An attempt was made to secure these fossils in sufficient quantities to show a complete life history of a species, as well as varietal differences, internal structure, etc.

Specimens obtained in such quantities are *Atrypa reticularis, Spirifer Hungerfordi, Spirifer Whitneyi, Atrypa aspera, Orthis Iowensis, Campophyllum namum, Spirifer orestes, Naticopsis gigantea* and *Strophodonta arcuata.*

Plate I, Series A shows the life history of the *Atrypa reticularis* from the young and minute forms up to the larger and older forms.

Series B shows the *Spirifer Hungerfordi,* and Series C shows the *Spirifer Whitneyi.*

Other specimens of these species were obtained, showing varietal differences, as well as internal structure.

Waterloo, Iowa.

The fossils obtained at Waterloo, Ia., are referred to the Devonian System, Hamilton Series. The exposure is just east of the city, where stone is being quarried for rough building stone.

The beds consist of a rather massive, yellow limestone containing considerable iron oxide. Fossils are numerous the greater part of which are corals of various kinds.

Plate II shows a few of the characteristic fossils of these beds—corals and brachiopods.

Most of the fossils have a dark brown color, due to the large amount of iron oxide in the disintegrated limestone in which they are embedded. Silicious geodes are abundant.

Fossils obtained in large quantities were *Atrypa reticularis*, *Acervularia profunda*, *Acervularia Davidsoni*, *Cystiphyllum Americanum*, and crinoid remains.

Plate III shows the *Acervularia profunda* and *A. Davidsoni* which are found, both embedded in the matrix and as free specimens.

Charles City, Iowa.

The sponge beds lying just east of the city, known as the Scripture Quarry, is referred to the Hamilton series.

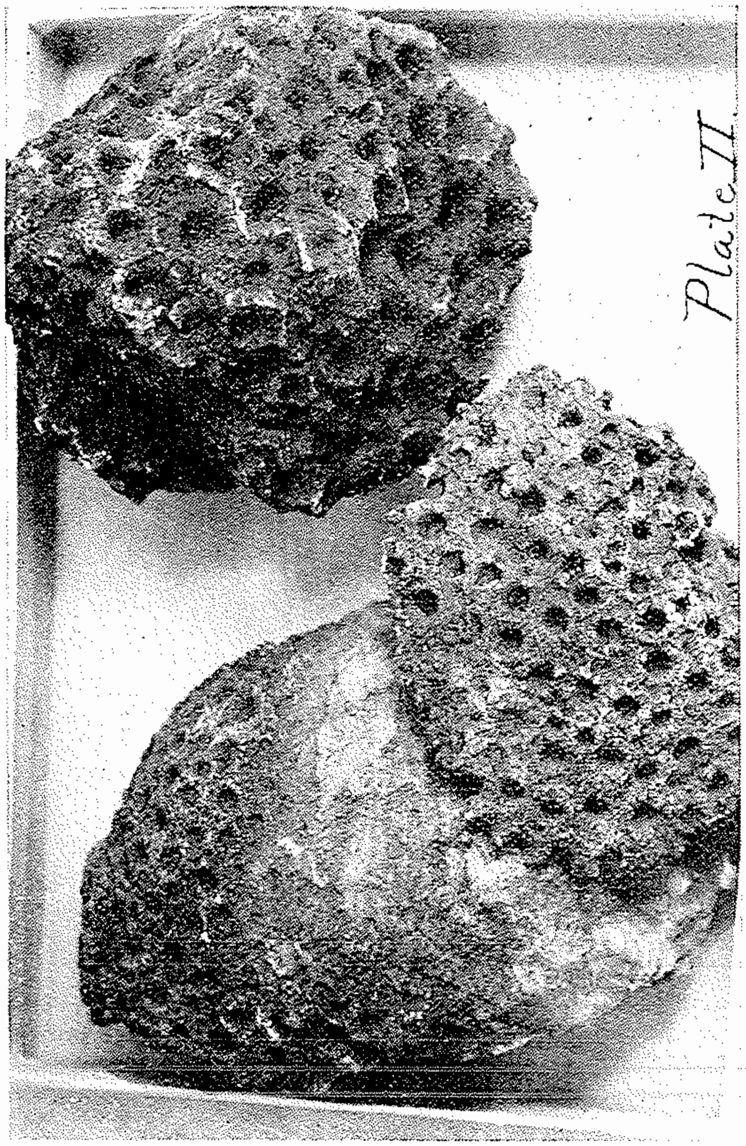
Sponges are abundant and are cemented with a calcareous material which is much softer than the fossils, and which allows them to weather out readily.

Some years ago quantities of this rock were sawed and polished and used for interior decoration, such as table tops and mantle pieces, but it was found that the matrix was too soft to hold the polish well, especially if used where water would come in contact with it.

The only specimens obtained from these beds were *Stromatopora* ——? although brachiopods and idiostroma were present. Those obtained vary in size from one inch in diameter to twelve inches in diameter.

In order to show their internal structure they should be cut and polished. In color they vary from a light yellow through

Plate 2



Fossils from Devonian System, Hamilton Series. Waterloo, Iowa

Plate 3

Fossils from Devonian System,
Hamilton Series. Waterloo, Iowa

The State Survey of South Dakota.

By Ellwood C. Perisho.

Numerous inquiries have been made of the State Geologist, as to the purpose, the work done, the problems to be investigated the organization, the needs, etc., etc., of the State Survey. Touching these questions, which should be known by every citizen, the following statements are gladly made:

Let it be understood by all that any money appropriated by the Legislature for the State Survey, becomes a part of the funds of the State and can not be used except by the issuing of requisitions endorsed by the Regents of Education, and can only be paid out in conformity with this requisition and when signed receipts showing an itemized expenditure are furnished the Auditor and Treasurer of the State.

Establishment of the Survey.

The law authorizing the establishment of the Survey designating the duties of the same, reads in part, as follows:

Section 2, Chapter 98, Session Laws of 1893.

"Said Survey shall be carried on with a view to a complete account of the mineral, vegetable and animal kingdoms, as represented in the State, together with its physical features, including the several geological strata, ores, soils, clays, coals, peats, artesian and other waters, marls, building and other stones, cements and other useful materials, scientific analysis of said materials, and report upon their economic value and accessibility, and further including tests by drilling, digging or other excavation for the discovery of water, iron, silver, gold, copper, coal, gas, salt, or other valuable mineral or other material that may from said surveys appear likely to exist in the State, including all native and naturalized grasses, herbs, plants, shrubs, trees, insects, birds, reptiles, fishes and mammals."

THE GENERAL POLICY OF THE SOUTH DAKOTA SURVEY.

*The first consideration of a State Survey, in determining the character of its work, would certainly depend upon the object of the Survey as set forth in the law, by virtue of which the Survey had its existence. While it may be possible, in some cases for the State Geologist to place various interpretations upon the exact meaning of the enactment creating the State Survey, and defining the object and the nature of its work, yet as a whole, no misunderstandings can occur. The real problem with the Survey, especially in a new State, is not to determine in what fields we are expected to work, but it is to decide just what investigation will be most valuable in consideration of the vast amount which might be done with the very limited means at the disposal of the Survey. What any State Survey should do is always dependent upon the natural resources of the State and the degree of their development in consideration of the needs of the people. But what a State Survey can do is dependent upon the resources of the Survey in men and money. As a rule, one might be safe in judging, that funds are appropriated with the view of utilitarian development of the resources of the State. No one will question the appropriations of such an aim, especially in an undeveloped State.

It should be the first duty of the survey to make an exploration of the State, in such detail as to discover the important economic products, the use of which would add to the comfort or convenience of the people. This exploration does not simply mean the discovery of valuable mineral wealth, but an investigation of the ore bodies, the coal seams, the clay beds, the cement deposits, the building stones, the oil fields, the gas belts, the artesian well areas, etc., in such a careful manner that there need not be such a waste of time and money in useless efforts to find these valuable minerals, on the one hand—nor upon the other, the lack of finding them. True it is that in our State many of the valuable resouces have been found, yet in a number of cases much valuable work can be done. This additional work will be in the nature of determining with the highest degree of accuracy, the manner of occurence, the geological strata, the distribution and the possible

* The following paragraphs are quoted from the Author's Article, published in The Journal of Economic Geology.

extent of the above named resources, or any mineral products of economic value. Not only the matter of quantity, but the question of accessibility should be determined. Can the people get it without too much cost? Location and general environment, both geological and geographical should be studied. It is the business of the Survey not only to find the useful materials, but to determine much more than their mere location. Can they be successfully utilized by the people is a question the Survey must answer.

The above work will of necessity involve the making of maps and the publication of reports. These should be of such a nature as to be of the greatest possible use to the largest number. A State Survey exists, not only for the few, but for many, hence it should benefit the masses as much as possible. While it is true that the work of the State Survey may be brought near to the people by the discovery of new and valuable industries, or by suggestion and exploration showing how unprofitable ones may be made to pay, and by charts, maps and reports, giving formations, conditions, statistics, yet there is a second great aim of a State Survey which must not be omitted—the educational phase of the work should be remembered as well as the utilitarian side. The Survey publications should be of especial value to the schools of the State. If the educational side of the Survey's work is not of the most importance, it certainly is of great value, or should be so considered.

A large amount of excellent work in such sciences as geology, botany, zoological and physical geography, can, and should, be done in our schools from data furnished by the Survey. This will have a two-fold benefit. It will give the pupils and students a better knowledge and hence a higher appreciation of their own State; and it will give to the people generally a better idea of the real worth of the work done by the Survey.

It is the policy of the Survey under its present management, to continue the excellent work previously done, along the lines specified by the law. With very small appropriations only a limited amount of work can be done during any one year; yet this is so planned that each successive year's work will supplement another in such a way that no time or effort will be lost. It is worthy of note that one important feature of the work of the Survey will never find its way into the published reports. This is the answering of a vast number of questions and inquiries concerning geological topics of local interest to the citizens of the State. The Survey is always glad to do this sort of thing for any body at any time.

In conformity with the law and the needs of the State, it is the wish of the Survey to continue the collection and mounting of the type forms of both birds and mammal life until we will have a good collection of our typical fauna and flora. Each year makes the accomplishment of this work more difficult, for every season diminishes the number of our native forms of life. It must be evident that a special effort should be made, and that very soon, if we are to have the sort of collection at all worthy of the rich and varied varieties of plant and animal life common to South Dakota.

The desirability of having a Museum in which the type forms of life, especially those found in our State, are properly mounted and labelled and correctly arranged, is so self-evident that it needs no argument. Such a collection and classification of the representative forms of life, would prove to be of great value simply as an educational factor. There is certainly no one in the State who would not only endorse this movement but would be glad to aid in its accomplishment.

As this feature of the Survey is for the good of all, it will most nearly approach the end for which we strive, if we can have the hearty co-operation of all those who can aid in making the collection.

Some Things the Survey Should Accomplish.

There are a number of vital questions which the Survey should help to solve for the people of South Dakota; if it can only have funds sufficient to do the work. Among them may be mentioned the following:

1. An investigation of the water supply of our State. Not so much the surface water of the rivers and lakes and shallow wells, but more especially that of our artesian wells. Few if any problems are of so great importance to the masses of our people as the question of maintaining our artesian water supply. The prob-

lem is a simple one. If we are drawing out of the Dakota sandstone more water than is going into this stratum, then it is only a question of time when our artesian wells will cease to flow. If the artesian water supply is inexhaustable, no matter how many wells are put down, then it will make no difference either as to the size of the well or the amount of water allowed to flow. Such a belief, however, one could scarcely entertain. The question of the flow of our wells should be studied through a long enough period of time to determine whether the wells will keep a reasonably uniform pressure and flow, under the same general condition, no matter what may be the length of time or the number of subsequent wells put down in the immediate vicinity. The rapidly increasing number, of new flowing wells, makes this question all the more worthy of consideration. The whole problem of the artesian well area, and the supply and flow of water should receive careful consideration, and then such legislation of restriction or regulation as will insure the preservation of this great natural resource of South Dakota.

2. In a prairie country like our own, no one economic product could add more to the comfort and convenience of the people than plenty of cheap fuel. The Survey wishes to investigate carefully the possibility of a more extended utilization of the natural gas supply, and to especially make a study of the coal-bearing areas. These should be investigated as to location, area, amount and character, etc. All the forms of either coal or lignite should be analyzed and the real value made known to the State.

3. South Dakota cement has a national reputation for its excellence. There can be no doubt but that there are many localities where just as good material for Portland cement exists as now found at Yankton. These beds should be known. This would prove a benefit not only to our own people but to those of other States. We have excellent brick and tile clays which more and more are coming into use. This State is rich in pottery, porcelain and fine-ware, clay deposits, which if properly known, might prove of great value.

The Work of the Survey for the Past Two Years.

Field Work.—Early in July, 1907, a party went into the Bad Lands of South Dakota for the puropse of collecting fossils, especially those of rare and extinct forms of mammals which are known to have lived in that region of the country in Tertiary times. Also to collect specimens of the living fauna and flora of that part of our State. This latter part of the work was largely confined to a collection of plants; and a study of these as to their character, relationship and general ecology. A third line of investigation was concerning the geological sturcture and character and past erosion history of the Bad Lands.

The above party consisted of the following:

Prof. James E. Todd, Vermillion, Geology.

Prof. S. A. Skinner, State School of Applied Sciences, Wahpeton, N. D., Botany.

Prof A. N. Cook, State University, Chemistry.

Mr. B. A. Iverson, Vermillion, Assistant in Geology.

Mr. Wm. E. Lattin, DeSmet, Assistant in Geology.

Mr. Edmund H. Sweet, Vermillion, Assistant.

Mr. D. Dwight Evans, Recluse, Assistant.

The State Geologist was with the party a part of the time.

One important result of the above trip the Survey succeeded, through the efforts of Prof. Skinner, in making an extensive collection of the flora of the region visited. This includes a number of new species which will prove of great interest and value to the science of botany. An extended report of Prof. Skinner's investigations will appear in Bulletin No. 5, of the State Survey Publications. As soon as these plants are all identified and the report completed, they will be placed in the Museum of the State University for future comparative study and reference work.

Another result of the Bad Lands expedition was the collection of a number of fossils. The Survey was disappointed in not being able to find complete skeletons of any of the large and very rare mamals. Yet this is not at all surprising in consideration of the time and changes operating upon the skeletons between the time of death and fossilization; and also the ravages of these same factors between the time the fossils were formed and the present. However, a number of excellent specimens were procured. Among these were: A partial skull of a titanotherium, a lower jaw of a titanotherium, a partial jaw of an oreodon, a fairly good jaw of a rhinocerous, an almost complete skull of a tiger, an imperfect skull of a fox-like animal, a number of teeth of different animals, a few good turtles, etc.

During a part of the summer of 1908, the Survey procured the services of Edmund H. Sweet and D. Dwight Evans, to continue the work of the collecting of fossils in the Bad Lands; and making additional observation and collections of the fauna and flora of that area. A number of valuable additions to the collections of 1907, have been made by the above gentlemen.

The Survey also employed Stephen S. Visher the past summer, to make a study of the geology along the creeks now being surveyed by the State Engineer's party in western South Dakota. Mr. Visher spent much time also in making observations and collections of the birds and plants in certain areas in and near the Black Hills, and in the Bad Lands. A report of his work will be published in a future bulletin of the State Survey.

Reports, Papers, etc. — In addition to the reports published in Bulletin No. 4, there are either now waiting or will soon be ready for publication, the following:

1. Reports on the Flora of the Bad Lands, South Dakota.
2. Paper on the Flora of South Dakota.
3. Analysis of Spring, River and Well Waters Found in Portions of Western South Dakota.
4. Report on the Flora of the Black Hills and Nearby Districts.
5. Catalogue of the Summer Birds of Western South Dakota.
6. A Preliminary Report on the Geology of the Bad Lands and other Portions of Western South Dakota.
7. Other Important Papers are in Preparation.

Funds Needed for the State Survey.

It is evident that the work for which our Survey was created, cannot be done without the necessary appropriations. Work along the above lines should be done as rapidly as possible. In addition to the field work we need money for printing. The above articles will be issued as soon as we have money for that purpose. South Dakota is a new State, but she is old enough to push the investigation of her mineral wealth. Iowa appropriates $8,000.00 a year for field work, besides a large amount for printing. Minnesota expends a larger sum than Iowa on her State Survey. North Dakota appropriate a smaller, yet a liberal amount. South Dakota should have, at least, $2,000.00 a year for her Survey. It would be better if the appropriation were so made that the funds could be used, if so desired, in conjunction with the United States Geological Survey. It is also desirable, if possible, that the funds set aside for the State Survey, be so given that they may be used at any time within the biennial period.

THE ORGANIZATION OF THE SURVEY.

In order that the State Survey may be more effective in its work, the following assistants were appointed by the Board of Regents:

In Zoology, Prof. C. P. Lommen of the State University.

In Chemistry, Prof. A. N. Cook of the State University.

In Botany, Prof. E. W. Olive, of the State Agricultural College.

Neither the assitants nor the State Geologist receive any compensation for the work done.

To briefly summarize, the most important work now before the Survey which should be done in the next few years, may be stated as follows:

1. The Investigation of the Artesian Water Supply, with Reference to its Conservation.

2. The Study, Analysis, etc., of the Coal, Oil and Gas of the State.

3. The Examination of Building Materials, including Stone, Cement and Clays.

4. The Investigation of the Fishes of Our Rivers with Reference to their Future Economic Value.

5. A Chemical Study of the Waters of South Dakota.

6. The Collection of Rare Fossils.

7. The Formation of a State Museum, Containing the Type Flora and Fauna of the State.

South Dakota is rich in her natural products; far more wealthy than many of us think. Too rich is she, not to make a larger use of her minerals. To the people of this State belong these treasures. It is the duty of the Survey, not only to discover such deposits, but to so investigate these that they will add to the material prosperity of all the people of this Commonwealth.

ELLWOOD C. PERISHO,
State Geologist.

Appendices to J. E. Todd's Article on the Geology of the Northwest-Central Portion of South Dakota.

Appendix A.--List of Fossils Collected by S. D. Geological Survey in 1902

Fox Hills.

Name.	Locality.	Remarks.
1. *Pteria linguaformis*	Little Eagle, Bull Head, Dirt Lodge.	Not uncommon throughout.
2. *Peteria fibrosa*	Bull Head.	Not common.
3. *Pteria Nebrascana*	Bull Head.	Not common.
4. *Gervillia recta*	Little Eagle, Bull Head, Moreau R.	Very common, everywhere.
5. *Modiola Meekii*	Little Eagle. Bull Head, Black Horse Cr.	Top and upper, rare.
6. *Nemodon sulcatus*	Little Eagle.	Abundant in places, lower.
7. *Cucullea Shumardi*	Moreau River.	Not uncommon, lower.
8. *Cucullea cordata*	Little Eagle.	Rare.
9. *Limopsisstratiopunctata*		Very abundant, mid. and lower.
10. *Nucula planimarginata*	Little Eagle. Bull Head.	Rare.
11. *Nucula cancellata*	Little Eagle, Bull Head.	Rare.
12. *Yoldia Evansi*	Bull Head.	Rare.
13. *Sphaeriola cordata*	Bull Head.	Rare.
14. *Tancredia Americana*	Bull Head. Dirt Lodge.	Abundant in places, top.
15. *Cardium speciosum*	Black Horse Cr.	Top, rare.
16. *Leptocardia subquadrata*	Little Eagle. Bull Head.	Rather rare.
17. *Callista Deweyi* (?)	Little Eagle. Bull Head.	Upper, common in spots.
18. *Tellina equilateralis*. (?)	Bull Head. (?)	Rare.
19. *Mactra formosa*	Little Eagle. Willow Cr.	Rare.
20. *Mactra Warrenana*	Little Eagle. Dirt Lodge.	
21. *Mactra alta*	Black Horse.	Upper, rare.
22. *Goniomya Americana*	Little Eagle.	Top, rare. Very rare.
23. *Neaera ventricosa*	Little Eagle.	Rare.
24. *Corbulamella gregaria*	Little Eagle, Bull Head, Moreau R.	Mid. and low., common.
25. *Entalis paupercula*	Little Eagle, Willow and Black Horse.	Top. abundant in spots.
26. *Haminea minor*	Bull Head.	Rare.
27. *Lunatia concinna*	Black Horse and Willow Crks.	Top, abundant in spots.
28. *Lunatia occidentalis*	Little Eagle. (?) Black Horse and Willow Crks.	Top, not common.
29. *Anchura Americana*	Bull Head.	Mid., abundant in spots.
30. *Chemnitzia cerithiformis*	Bull Head.	Rare.
31. *Spironema tenuilineata*	Little Eagle, Bull Head.	Not uncommon.
32. *Pyrofusus Newberryi*	Little Eagle, Bull Head, Elm Waterholes.	Lower, not uncommon.
33. *Pseudobuccinum Nebrascense*	Little Eagle, (?) Bull Head.	Rare.
34. *Fasciolaria buccinoides*	Little Eagle, Bull Head.	Not common.
35. *Fasciolaria Scarboroughi*	Willow Cr. Dirt Lodge.	Rare.
36. *Fasciolaria Culbertsoni*	Willow Cr., Bull Head.	Rare.
37. *Pyropsis Bairdi*	Bull Head.	Lower, not uncommon.
38. *Fusus Dakotaensis*	Little Eagle, Bull Head, Elm Waterholes.	Rare.
39. *Turritella* —— ?	Bull Head. ?	Very rare.
40. *Scaphites nodosus, quadrangularis*	Bull Head, Moreau R.	Rare.

Name.	Locality.	Remarks.
41. *Scaphites brevis*	R., Fog Ridge.	Common.
42. *Scaphites Conradi* ..	Bull Head.	Abundant in places.
43. *Scaphites Conradi, gulosus*	Little Eagle, Bull Head.	Abundant in places.
44. *Scaphites Nicolletii*...	Little Eagle, Bull Head, Moreau R.	Very abundant in lower.
45. *Scaphites Cheyennensis*		Rare.
46. *Scaphites Mandanensis*	Little Eagle, Bull Head, Meadow Cr., etc., etc.	Very common throughout.
47. *Placenticeras lenticulare*	Little Eagle, Bull Head, Meadow Cr., etc., etc.	Small, common, everywhere.
48. *Nautilus DeKayi Montanensis*	Little Eagle, Bull Head, Moreau R., etc.	Top-base, not common.
49. *Belemnitella bulbosa* (?)	Little Eagle.	Much larger than typical form, over half inch diameter.
50. *Corax pristodontus* tooth	Elk Butte.	Top, only one specimen.
51. *Dryplosaurus* —— ..	Little Eagle.	Middle, crown about one inch long.

Little Eagle locality visited this year northwest of the Government School, seems to present the whole height of the Fox Hills. The hills south of town are also rich and probably an examination of Elk Butte would show similar abundance.

Bull Head locality, which we examined under unfavorable circumstances because of the flood, is west of the Station and above the mouth of Spring Creek. There are high bluffs from the top of the Fox Hills nearly to base and the fresh concretions have collected on an extensive bar a little below. The locality is by no means exhausted.

Dirt Lodge locality is a little below the mouth of that creek on north side of Grand River. A section is given elsewhere.

Meadow Creek locality is at a butte east of that creek about 2 miles north of the Moreau.

Elm Water holes locality is on the north edge of Fox Ridge table land south of White Horse camp.

Black Horse Creek locality is opposite the mouth of that stream on the north side of Grand River. Many localities probably equally productive might be indicated, but these are representative and where most of our collections were made.

All specimens were found in concretions or in sandstone, none loose in the clay, apparently.

Laramie.

Name.	Locality.	Remarks.
1. *Anomia* ——	Dog Butte.	Not uncommon.
2. *Ostrea glabra*	Dog Butte, Thunder Butte Cr. and Grand R.	Very abundant in places.
3. *Corbicula subelliptica*	Dog Butte, near mouth of Black Horse.	Abundant in spots.
4. *Corbicula cythereaformis*	Dog Butte.	Not uncommon.
5. *Corbicula occidentalis*	Dog Butte.	Not uncommon.
6. *Tellina scintula*	Dog Butte.	Rare.
7. *Melampus* ——	Near mouth of Black Horse.	Rare.
8. *Melania insculpta*...	Near mouth of Black Horse.	Not uncommon.
9. *Neritinavolutimitra* .	Near mouth of Black Horse.	Rare.
10. *Melania* ——	Near mouth of Black Horse.	Rare.
11. *Planorbis* ——	Arrow Head Hills, D. & B. Trail.	Abundant in flint.
12. *Limnea* ——	Arrow Head Hills, D. & B. Trail.	Abundant in flint.
13. *Unio priscus* ?	Cottonwood Cr.	Casts in limonite, abundant.
14. *Unio* ——	Cottonwood Cr.	Casts in limonite, not common.
15. *Triceratops* —— ...	Cottonwood Cr., Dirt Lodge Cr.	Fragments of large bones.
16. Turtle.	Cottonwood Cr.	Fragments.
17. Petrified wood.	Cottonwood Cr.	Common.
18. Fossil fruit	Grand R. above mouth of Cottonwood.	
19. Fossil leaves.	On divide between upper Bear Cr. and Moreau.	

Appendix B.

Representative Sections.

The following sections are selected to give definite illustrations of the succession of strata and their general characters. We have found it convenient to begin at the western part of our area with the highest formations. In order to give one some idea of the stratigraphical position of each section, we give the estimated altitude of the top of each section. These estimates are based upon barometric readings.

SECTION OF THE SOUTHEAST END OF SLIM BUTTES.

TOP ABOUT 3,500 FEET.

This was taken by the writer in 1895, when more attention was made to the Tertiary formations. Mr. Ellis found beds of lignite in the Laramie in 1902 which escaped our earlier observation.

Miocene.	Feet
18. Clay, top of it flat with fragments of limestone...	9
17. Coarse sandstone	2
16. Whitish clay	38
15. Light gray sandstone	4
14. Fine argillaceous sand rock	50
13. Coarse sandstone	9
12. White argillaceous limestone, lower six inches full of fossils of fresh water shells, very hard and sonorous	2 to 3
11. White clay	18
10. Sandy white clay	8
Oligocene.	
9. Fragments of buhrstone or yellow flint with plant stems	1
Laramie.	
8. Yellow clay with an 8-ft. layer of lignite near the middle	50
7. Yellow sandy loam	5
6. Light gray sandstone with a layer of large calcareous sandstone concretions on top	4
5. Light colored clay sand with smaller concretions.	9
4. Dark clay	10
3. Light gray plastic clay	7
2. Yellow sandy loam with several layers of calcareous sandstone concretions	54
1. Dark gray plastic clay	15
Total	296

SECTION OF RABBIT BUTTE. TOP ABOUT 3,000 FEET A. T.

Laramie.	Feet
34. Rusty loamy sand with many small nodular concretions with portions consolidated about the middle with a darker band	42
33. Heavy flat concretions of small size	½
32. Loamy sand as above	6
31. Laminated and rippled light gray sandstone.....	1½

30.	Light gray shady clay (chalky) with 2 feet blackish shale near the top	8
29.	Yellow sand with quite regular small round concretions 4 to 10 inches in diameter	14
28.	Light gray loamy sand	2
27.	Black carbonaceous flaky shale	2
26.	Light gray laminated clay	3 to 4
25.	Scattered calcareous concretions clearly laminated	1
24.	Light gray loam	6
23.	Layer of concretions, rusty below	1
22.	Light gray loam or white sand	15
21.	Black laminated shale	1
20.	Light gray sand	5 to 7
19.	Laminated gray shale with 3 inches of Lignite in the middle	2
18.	Light gray, flaky shale	5
17.	Whitish loam or white sand	3 to 4
16.	Laminated shale, black in the middle	1½
15.	Yellow loam or fine sand	6
14.	Black shale	2½
13.	Light gray shale	3
12.	Yellow loamy sand	4
11.	Light gray shale	8
10.	Black shale	2
9.	Light gray clay	5
8.	Yellow sandy clay with blue layers	3 to 4
7.	Plastic clay, checky	4
6.	Sandy clay with large rusty concretions near the top 1 foot thick and a layer 2 to 3 feet in diameter near the bottom	15
5.	Dark drab clay, flaky in some places	18
4.	Light gray sand	2
3.	Light gray, flaky clay	3
2.	Stratified light gray loam	1
1.	Shaly clay with various colors, blue and drab	34
	Slope to Rabbit Creek	162
	Total	392 to 397

SECTION NEAR RABBIT BUTTE. TOP ABOUT 2,800 FEET A. T.

17.	Shaly fine sandstone	1
16.	Fine sandstone, more massive	6
15.	Drab flaky shale 1 inch of lignite at the top	2 to 3
14.	Whitish and yellowish loamy sand	3 to 4
13.	Almost continuous shaly concretions	1½
12.	Yellow sand	8
11.	Undetermined	57
10.	Fine sandy loam	6
9.	Gray laminated irregular sandstone	1
8.	Stratified fine sand	1
7.	Drab checky clay	8 or 9
6.	Undetermined	15
5.	Rusty stratified and at joint muddy sand	5
4.	Light drab plastic clay with a few 6-inch concretions	11
3.	Dark shaly clay	3
2.	Light soft fine gray sandstone at irregular concretions 1 and 2 feet in diameter 6 feet below the top	16
1.	Drab with 16 inches of lignite toward the bottom. Level of Rabbit Creek northwest of the butte.	6

SECTION OF ARROW HEAD HILLS. TOP ABOUT 2,665 FEET A. T. (KNIGHT.)

3.	Gray clay with lighter tints toward the bottom and stratified horizontally	55
2.	Zone of flint concretions with fossil fresh water shells forming the capping of isolated knolls to the South	2 to 3
1.	Horizontalliy banded light and dark clay and loamy clay with a sandstone dyke in the lower portion, showing in the western flank of the Hills	126

SECTION OF THUNDER BUTTE. TOP 2,830 FEET A. T. (KNIGHT.)

About 580 feet above the junction of Flint Rock Creek and Moreau River.

17.	Hard light gray and rusty sandstone, in places obliquely laminated and also micaceous and rippled	55
16.	Yellow massive sandstone	8
15.	Lead colored gumbo with loamy layers	5
14.	Undetermined	15
13.	Yellow loamy clay	25
12.	Gray gumbo, somewhat loamy; rusty below	18
11.	Clay	2
10.	Yellow loamy sand with sandstone concretions at different levels	64
9.	Gray clay	5
8.	Undetermined	25
7.	Light gray clay	10 to 15
6.	Carbonaceous shale dark above and harder below.	4
5.	Rusty loamy clay	2
4.	Undetermined	2
3.	Drab checky gumbo	3
2.	Whitish clay	1½
1.	Dark gray clay	3
	Total	217½ to 222½

SECTION OF THE BUTTES NORTH OF BIXBY.

ALTITUDE 2,900 FEET A. T. (KNIGHT.)

9.	Three feet shaly sandstone	3
8.	Sandy loam	12 to 15
7.	Shaly sandstone	2
6.	Yellow loam and drab clay interstratified	
5.	Clay with concretions	9
4.	Yellow loam	10
3.	Drab	15
2.	Light gray loamy clays with layers of rusty sandstone and few pyrite concretions with occasional layers of sandstone	36
1.	Gray clay with some layers darker	35
	Total	132 to 137

SECTION BELOW JUNCTION OF FLINT ROCK AND MOREAU. TOP ABOUT 2,350 FEET A. T.

3. Alluvium and gravel, top estimated to be 160 feet above Moreau River 15

Laramie.

2. Sand with zone of large concretions about 35 feet below the top 60
1. Sandy clay with no fossils above, but near the bottom Nautilus DeHayi, Scaphites, Ostrea, Placenticeares marking probably the top of the Fox Hills 85

COMBINED SECTION OF THE BUTTES NEAR MEADOW CREEK NORTH OF THE MOREAU. TOP ABOUT 2,400 FEET A. T.

Laramie. Feet.

10. Yellow sandstone passing into sandy loam below, the sandstone has many root marks and casts of stems 1/8 to 1 inch in diameter................ 23
9. Loamy clay with a few small concretions 25
8. Layer of heavy irregular concretions Placenticeares and Cuculea 6
7. Buff loamy sand, grayish loam 35
6. Gray sand with larger concretions and small Scaphites 8
5. Layer of large flat irregular rusty concretions, no fossils 1
4. Darker gray loamy clay Pterialaviatus 11
3. Another stratum of concretions 1
2. Light buff loam sand with gypsum crystals 27

Pierre.

1. Darker clay with several concretionary layers, probably Pierre 32

SECTION OF BLACK HORSE BUTTE. TOP 2,640 FEET A. T. (KNIGHT.)

25. Whitish gray sandstone 36
24. Sand 24
23. Undermined, but probably largely clay with some lignite toward the top, as Willis reports it...... 62
22. Green colored loam .... 8 to 10

21.	Blackish clay	3
20.	Rippled sand and sandstone	2 to 3
19.	Rusty yellow sand	5
18.	Light loamy clay	4
17.	Blackish shale with some lignite (?)	3
16.	Whitish loamy sand	25 to 27
15.	Black shale	3
14.	Light buff loam	9
13.	Dark plastic clay	11
12.	Yellowish gray sand	6
11.	Light gray plastic clay	1½
10.	Very impure lignite	1
9.	Plastic gray clay with lignite below	8
8.	Brownish loam with yellow iron concretions	5
7.	Undetermined, but probably sand	9
6.	Yellow loam	15
5.	Stratum of rusty concretions	1
4.	Light gray plastic clay	6
3.	Laminated ripple marked shale	2
2.	Light and dark clays with a black stratum at the bottom 1 foot thick	36
1.	Light and drab plastic clay	20
	Total	305½-310½

SECTION ON GRAND RIVER NEAR THE CROSSING OF THE BISMARCK AND DEADWOOD TRAIL. TOP 2,200 FEET A. T.

Laramie.		Feet.
4.	Terrace composed mostly of sand	50
3.	Limonite	1-3
2.	Three feet black shale with much of it lignite in some places	3
1.	Gray sand	3
	Level of Grand River.	

SECTION LITTLE BELOW MOUTH OF BLACK HORSE CREEK. TOP 2,210 FEET A. T.

4.	Top of terrace about 130 feet above Grand River sand	5

3. Gravel 4

Laramie.

2. Gray sand 85

1. Gray sandy clay with corbiculas near the top

Fox Hills.

Ostrea, *Melampus* and below *Scaphites*, *Mactra*, *Lunatia*, *Cardium*, etc., mark the top of Fox Hills 40

Level of Grand River.

SECTION ON WILLOW CREEK. TOP 2,175 FEET A. T.

4. Top of the terrace about 125 feet above Grand River, gravel and alluvium .... 6 to 10

Laramie.

3. Loamy clay brown above and darker below 18

2. Rusty sand with some concretions, *Lunatia* and *Corbicula* 20

Fox Hills.

1. Dark clay and sand interstratified with patches of fossils, *Lunatia*, *Entalis*, etc. 33

Fifty feet above Grand River.

SECTION BELOW THE MOUTH OF DIRT LODGE CREEK.

TOP 2,110 FEET A. T

5. Top of terrace about 100 feet above Grand River, gravel

Fox Hills.

4. Gray clay and yellow sand interstratified no fossils 10 to 15

3. Hard concretionary sandstone .... 3 to 6

2. Rusty massive sandstone *Tancredia* above and *Pteria* and *Fusus* below 25

1. Sand .... 10 to 15

Thirty feet to the level of the river.

SECTION AT SPRING CREEK NEAR BULL HEAD. TOP 2,122 FEET A. T.

9. Top of the terrace about 190 feet above the stream slope and yellow sand 30

Laramie.

8. Sandstone, no fossils. ....

7. Yellow sand 8
6. Clayey sand 25

Fox Hills.

5. Concretionary sandstone *Tancredia, Callistra,* etc. 3 to 5
4. Yellow sand .... 12 to 15
3. Yellow sand capped with a thin zone of flat concretion 36
2. Gray clay with fossils in 2 or 3 layers of concretions 22
1. A gray clay with 3 or 4 layers of concretions about 10 feet apart 35 feet, *Grevillia, Anchura, Scaphites* and many other species 15

Level of Grand River.

SECTION NORTHWEST OF LITTLE EAGLE. TOP 2,080 FEET A. T.

Fox Hills.

4. Rusty sandstone with *Callista* near bottom..... 27
3. Undetermined 19
2. Sandy clay containing several layers of concretions with many fossils characteristic with Fox Hills 100

Pierre.

1. Dark plastic and laminated clays .... 20 to 30

Total .... 166 to 176

To the level of Grand River 165 feet.

SECTION OF ELK BUTTE. TOP 2,225 FEET A. T.

Laramie. Feet.

9. Gray sandstone with some fossil wood 5
8. Yellow sand .... 45 to 50
7. Dark clay 10
6. Yellow clay 30
5. Sand and sandy loam with concretions 5
4. Sandstone .... 1 to 3
3. Undetermined 17
2. Sandy clays with concretions 20
1. Dark laminated plastic clays 180

Total .... 361 to 369

Appendix C.

Sections of Deep Wells.

SECTION OF THE DEEPEST WELL AT PIERRE.

A careful record of a well sunk at Pierre by the Natural Gas and Power Co. was published in Bulletin No. 2, Page 93. At that time it was believed that granite was struck at 1,260 feet. In 1902 Norbeck and Nicholson were engaged to sink another well for gas and not far from the former well, and found no granite, but the following additional strata.

	Formation	Thickness, Feet.	Depth, Feet.
23.	Continuing, streaks of white shale and sandstone	75	1320
24.	Fine laminated soft sandstone	130	1450
25.	Black shale with about 10 feet of lignite interstratified	84	1534

The lignite resembled cannel coal in part though much of it was quite impure. This was reported by Dr. D. W. Robinson.

LOG OF WALDLEIGH WELL BY C. L. NICHOLS

TOP ESTIMATED 1,800 FEET A. T., SW. 32—113—79.

	Formation.	Thickness, Feet.	Depth, Feet.
1.	Black soil and gravel	2	2
2.	Yellow clay quite gravelly	28	30
3.	Black clay	160	190
4.	Blue shale with slabs of slate	420	610
5.	Black shale with occasional slabs of slate	70	680
6.	Very hard sandstone (coarse gravel)	40	720
7.	Very hard sandstone	65	785
8.	Blue shale with thin layers of limestone	215	1000
9.	Gray shale	60	1060
10.	Blue shale with occasional shells of limestone and slate	340	1400
11.	Hard stone, with first flow	2	1402

12.	Shale, sandy and streaks	108	1510
13.	Fine sand rock with a few hard strata, second flow	55	1565

Gas was obtained at about 600 feet, though more came with the water.

LOG OF ONIDA WELL BY C. L. NICHOLSON.

TOP ESTIMATED 1,850 FEET A. T.

	Formation.	Thickness, Feet.	Depth, Feet.
1.	Black soil	3	3
2.	Yellow clay with pockets of gravel....	31	34
3.	Blue clay with gravel pockets	136	170
4.	Blue shale with hard shells of slate and limestone	780	950
5.	Hard sandstone	8	958
6.	Black shale with slate	242	1200
7.	Gray shale	60	1260
8.	Blue shale slabs of slate and limestone.	140	1400
9.	Shale sandy and streaks first flow.....	160	1560
10.	Sand rock with a few hard shells second flow at 1630	157	1717

LOG OF PEARL TOWNSHIP WELL NO. 1, BY CHARLES L. NICHOLSON, WELL DRILLER. TOP OF WELL ESTIMATED 1,870 FEET A. T. ON NE. QUARTER, SEC. 28—115—79.

	Formation.	Thickness, Feet.	Depth, Feet.
1.	Black soil	3	3
2.	Yellow clay	31	34
3.	Blue clay	176	210
4.	Blue shale with slabs of slate from 2 to 20 feet thick	756	968
5.	Shells of limestone	2	970
6.	Shale	50	1020
7.	Limestone	8	1028
8.	Shale	25	1080

9.	Blue shale with gray streaks and occasional thin limestone layers	505	1585
10.	Sand rock	195	1780
11.	Very hard rock	1	1781

PEARL TOWNSHIP NO. 2, NE. SEC. 3—115—79, BY C. L. NICHOLSON.

	Formation.	Thickness, Feet.	Depth, Feet.
1.	Black soil	2	2
2.	Yellow clay	29	31
3.	Blue Clay	169	200
4.	Gravel	10	210
5.	Blue shale with slate and pyrites	1030	1240
6.	Hard limestone	25	1265
7.	Hard rock	30	1295
8.	Gray and blue shale with shells of limestone	230	1525
9.	Sand rock with many hard layers	188	1713
10.	Very hard rock	1	1714

SECTION OF GETTYSBURG WELL, A FEW MILES EAST OF OUR AREA.

TOP 2,082 FEET A. T.

1.	Black soil	2	2
2.	Yellow clay	28	30
3.	Blue clay	150	180
4.	Blue shale with many thick shells of slate	1250	1430
5.	Very hard rock	40	1470
6.	Sandy shale with many nodules of pyrites	90	2130
7.	Sand rock	210	1980
8.	Sandy shale	20	2000
9.	Sand rock	40	2040
10.	Alternate layers of sand rock and shale	90	2130

Water rises to within 108 feet of the surface.

The record of the well at Cheyenne River Agency will be found in Bulletin No. 2. It has stopped flowing apparently because of the rusting out of the pipe.

SECTION OF SELBY WELL. TOP 1,874 FEET A. T.

FURNISHED BY FRED GRIFFIN.

Formation	Thickness, Feet.	Depth, Feet.
1. Soil and loam	5	5
2. Till or boulder clay	80	85
3. Shales	1655	1740
4. Sandstone flow from 1880	150	1890

Water rises 38 feet above the surface.

The first well of H. H. Hunter at Campbell Postoffice with an altitude of 1,590 has a depth of 1,885 with flows from 1,790 to 1,820; pressure about 100 pounds.

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